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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

AN INVESTIGATION OF THE HYDRODYNAMIC CHARACTERISTICS OF A 1/10-SIZE POWERED DYNAMIC MODEL OF THE MARTIN M-267 PATROL-TYPE SEAPLANE WITH TWO FOREBODY CONFIGURATIONS

TED NO. NACA DE 376

By Elmo J. Mottard and Claude W. Coffee, Jr.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation was made of the hydrodynamic characteristics of a 1/10-size powered dynamic model of a patrol-type seaplane designed by the Glenn L. Martin Company. The seaplane had a high-aspect-ratio wing and a T-tail with an all-movable stabilizer. The hull combined high length-beam ratio, small cross section, a "low chine" bow, a warped-dead-rise forebody, a faired 60° V-step, and a long warped-dead-rise afterbody. A comparison was made between two forebody configurations, one having a sharp forebody keel in cross section and the other having the forebody cross section rounded in the vicinity of the keel.

Stable take-offs were possible with both configurations in smooth water for the aerodynamically practical range of positions of the center of gravity. The landing stability in smooth water was satisfactory for both configurations. The flaps and propellers were clear of spray during the smooth-water investigation except over a short speed range. The T-tail was generally clear of spray. The rough-water landing behavior appeared to improve with increasing landing trim. The differences in the rough-water landing characteristics of the two configurations were small.

INTRODUCTION

The Glenn L. Martin Company M-267 is a long-range, propeller-driven, patrol-type seaplane having a high-aspect-ratio wing and an all-movable T-tail. The hull combines for the first time several hydrodynamic features of interest including a high-length-beam ratio hull of small cross section, a "low-chine" bow, a warped-dead-rise forebody, a 60° V-faired step, and a long warped-dead-rise afterbody extending to the tail. These features have been shown separately to have certain hydrodynamic advantages.

In order to determine the overall hydrodynamic characteristics of the design, the Bureau of Aeronautics, Department of the Navy, requested that a tank investigation be made. A 1/10-scale powered dynamic model was designed and built by the David Taylor Model Basin and was tested in Langley tank no. 1.

The model included two forebody configurations proposed by the Martin Company. The first had conventional V-cross sections with chine flare. The second had the same cross sections except that they were rounded off at the keel. The rounded sections approximated those proposed in the past (refs. 1 and 2) for obtaining constant force during landing impacts and, consequently, lower peak impact loads.

The hydrodynamic qualities of the model determined in the investigation included the trim and center-of-gravity limits of stability, landing stability, spray characteristics, and motions and accelerations during landings in various sizes of waves. These qualities were obtained for both forebody configurations to study unknown effects of the rounded keel other than the possible reduction of peak water loads predicted by water impact theory.

SYMBOLS

$\bar{c}$ mean aerodynamic chord, ft

C_L aerodynamic lift coefficient, $\frac{L}{\frac{1}{2}\rho V^2 S}$

g acceleration due to gravity, 32.2 ft/sec^2

L aerodynamic lift, lb

n_V vertical acceleration, g units

S	wing area, sq ft
V	horizontal velocity, ft/sec
V_s	vertical velocity (sinking speed), ft/sec
α	angular acceleration, radians/sec^2
γ	flight-path angle, deg
δ_f	flap deflection, deg
δ_s	stabilizer deflection, deg
Δ_o	gross load, lb
ρ	density of air, slugs/cu ft
τ	trim (angle between the horizontal and sharp keel at the step), deg
τ_L	landing trim, deg

DESCRIPTION OF MODEL

Photographs and the general arrangement drawings of the model are shown in figures 1 and 2, respectively. Pertinent characteristics and dimensions of the model and the full-size seaplane are given in table I. The hull lines are shown in figures 3 and 4. The basic forebody configuration had a sharp forebody keel in cross section and a dead rise at the step of 22° which increased progressively toward the bow. The modified configuration was obtained by rounding the sharp keel in cross section for a distance forward of the step of approximately 6 beams. The round-bottom sections are tangent to the original bottom at a point approximately 10 percent of the beam from the hull center line (fig. 4). Rounding of the forebody keel resulted in a slight decrease in forebody volume and approximately $\frac{1}{2}^{\circ}$ higher forebody keel angle at the step.

The trim angle for the two configurations was taken as the angle between the horizontal and a line parallel to the sharp keel of the basic configuration.

The hull was constructed of balsa and covered with a plastic-fiberglass laminate. A parting line was provided above the chine on the forebody to allow the installation of either forebody bottom.

Interchangeable fairing blocks were provided behind the step in order to maintain the same step depth (0.025-inch, model size) with either forebody configuration.

Conventional balsa and tissue construction was used on the wing and tail surfaces. Leading-edge slats were attached to the wing in order to delay the stall to an angle of attack more nearly equal to that of the full-size seaplane. The flaps were of the single-slot type extending over 80 percent of the wing span. The stabilizer on the T-tail was controllable and was linked with the elevator in such a manner that the elevator deflection was twice the stabilizer deflection.

The dynamic model was powered by two $1\frac{1}{2}$-horsepower three-phase alternating-current induction motors. Each motor turned a three-blade metal propeller.

The moments of inertia of the ballasted model were as follows:

Center-of-gravity position, percent $\bar{c}$	Moment of inertia, slug-ft^2
12	6.9
24	6.9
36	7.5

These values are comparable to those of similar seaplane models. The full-size moments of inertia were not available.

APPARATUS

A description of Langley tank no. 1 and the towing carriage is given in reference 3. The setup of the model on the towing gear is shown in figure 5. The model was free to move vertically and was free to trim about a pivot located at the center of gravity but was restrained in roll, yaw, and lateral movement. During landings in smooth and rough water the model had approximately 5 feet of fore-and-aft freedom with respect to the towing carriage.

Slide-wire pickups were used to measure trim, rise of the center of gravity, and fore-and-aft position of the model. Aerodynamic lift was measured with a spring dynamometer. The model trim during landings was restrained by an electrically operated trim brake attached to the

towing staff. The brake was automatically released when the model contacted the water.

A strain-gage-type accelerometer mounted on the towing staff was used to measure vertical acceleration. In the static condition the accelerometer read zero. Two strain-gage-type accelerometers, mounted 7 inches apart and connected in such a manner that they measured the angular accelerations directly, were located within the model with their centers of gravity in line with the model center of gravity. The characteristics of the accelerometers and galvanometers used for recording the accelerations were as follows:

	Angular	Vertical
Natural frequency of accelerometers, cps	120	180
Natural frequency of recording galvanometers, cps	103	30
Damping of accelerometers, percent of critical	70	70
Damping of recording galvanometers, percent of critical	65	65

Waves were generated by the Langley tank no. 1 wavemaker which consists of an oscillating plate hinged at the bottom of the tank and driven by an electric motor. The desired height and length of wave were obtained by a suitable combination of amplitude and frequency of the plate.

PROCEDURE

All model quantities have been converted to full size except where otherwise noted.

Effective thrust.- The effective thrust of the model (defined as the total aerodynamic drag, power off, plus the resultant horizontal force with power on) was determined at 3° trim, 30° flap deflection, 0° stabilizer deflection, and with the step of the model approximately 9 inches (model size) above the water surface. The model thrust was matched to the full-size thrust at a speed of 59 knots.

Trim and aerodynamic lift.- At high speeds the trim and aerodynamic lift, with and without power, for various flap and stabilizer deflections and positions of the center of gravity were measured with the model free to pivot about the center of gravity and supported in the position used

for the determination of the effective thrust. At low speeds the model was aerodynamically unstable, so the aerodynamic lift was determined with the trim fixed.

Trim limits of stability.- The trim limits of stability were determined with and without power during constant speed runs. At each speed, the trim of the hull was changed by adjusting the stabilizer position until porpoising was noted or until the maximum or minimum stabilizer deflection was obtained. The trim at which porpoising was first observed was taken as the limit of stability.

Center-of-gravity limits of stability.- The center-of-gravity limits of stability for various stabilizer deflections, 30° flap deflection, and two gross loads were determined during accelerated runs to take-off speed with full power. A constant rate of acceleration of 4 feet per second per second was used for the 70,000-pound load and 3 feet per second per second for the 85,000-pound load. The accelerated runs were made at several center-of-gravity locations. As a safety precaution, a trim stop was provided which prevented the model from trimming lower than 1°.

Landings in smooth water and waves.- The landing behavior in smooth water and waves was determined by flying the model at the desired landing trim and by decelerating the carriage at a uniform rate so that the model was allowed to glide onto the water in simulation of an actual landing. The model was held at the desired landing trim by the trim brake which was released electrically upon contact with the water. This procedure eliminated the tendency for the trim to decrease as the model approached the water surface. The landings were made without power and the stabilizers were set so that the aerodynamic pitching moment about the center of gravity would be approximately zero at the instant of first contact. The landings were made with the model free to move forward and rearward and the deceleration of the towing carriage was adjusted so that the model had longitudinal freedom within the limits of the stops on the fore-and-aft gear. All landings were made with the flaps deflected 30°. At the design gross load of 70,000 pounds, smooth-water landings with the round-keel configuration were made at various center-of-gravity positions (from $0.12\bar{c}$ to $0.36\bar{c}$). At the overload (85,000 pounds) condition, landings were made at one center-of-gravity position ($0.24\bar{c}$). The sharp-keel configuration was landed at one center-of-gravity position ($0.24\bar{c}$) for both gross loads. All landings in waves were made at a gross load of 70,000 pounds with the center of gravity at $0.24\bar{c}$.

Spray characteristics.- Smooth-water spray characteristics of various gross loads, with full power, were determined during slow accelerated runs (approximately 1/4 ft/sec^2) up to 43 knots. Photographs and visual observations were made of the bow spray in the propellers and striking the flaps. Measurements of the draft of the point of the step and trim were made during these runs.

RESULTS AND DISCUSSION

Aerodynamics

The effective thrust is plotted against speed in figure 6.

The free-to-trim aerodynamic lift coefficients for the power-off condition are plotted against trim in figure 7 for two flap deflections. The lift coefficients obtained during power-off tests were greater for the 30° flap deflection than for the 45° flap deflection, and all subsequent tests, therefore, were made with the 30° flap deflection. The power-on aerodynamic lift and stabilizer deflection are plotted against trim for two center-of-gravity positions ($0.12\bar{c}$ and $0.24\bar{c}$) in figure 8. The data at speeds less than 56.1 knots were obtained with the model fixed in trim, and at speeds of 56.1 knots and greater the model was free to trim.

Hydrodynamics

Trim limits of stability.- The trim limits of stability are presented in figures 9 and 10 for the two configurations. In general, the behavior of the two configurations did not differ appreciably. At high trims, water tended to stick and flow along the afterbody, and the upper trim limit (decreasing trim) was hard to define because a large change of trim occurred when the afterbody flow was broken. At the heavier load the limits occurred at higher trims, and no upper limit was obtained. The trim limits for the round-keel configuration occurred at lower trims than those obtained with the sharp-keel configuration.

Center-of-gravity limits of stability.- Representative trim tracks for the two configurations are given in figures 11 and 12 for various stabilizer deflections. A few of the trim tracks are apparently influenced by the trim stop which limits the trim to 1°. In general, the round-keel configuration tended to trim lower than the sharp-keel configuration throughout the take-off range. Although the trim tracks at the higher stabilizer deflections intersected the upper trim limit, the upper-limit porpoising generally did not exceed an amplitude of 2°. Both configurations tended to trim up rapidly before take-off when flow attached to the afterbody.

The maximum amplitudes of porpoising that occurred during take-off were determined from the trim tracks and plotted against center-of-gravity position in figure 13. The maximum amplitude is defined as the difference between the maximum and minimum trims during the greatest porpoising cycle that occurred during the take-off. By assuming a maximum allowable amplitude of porpoising of 2° for satisfactory take-off

characteristics, the center-of-gravity limits shown in figure 14 were obtained. These center-of-gravity limits are presented as a plot of stabilizer deflection against center-of-gravity position. Because it was assumed that the effect of the keel modification on the center-of-gravity limits would be negligible, it was considered sufficient to obtain these results for only one of the configurations. Consequently, complete center-of-gravity limits were obtained only for the round-keel configuration. Center-of-gravity limits for the sharp-keel configuration, obtained only for the more practical positions of the center of gravity, showed good agreement with the results for the round-keel configuration. Within the range of positions of the center of gravity from $0.12\bar{c}$ to $0.36\bar{c}$, stable take-offs were possible for the two gross loads. A forward center-of-gravity limit was imposed by lower-limit porpoising but no rearward limit was encountered. The effect of increased load was to move the forward center-of-gravity limit forward.

Smooth-water landings.- Sinking speed, flight-path angle, maximum vertical acceleration, and maximum angular acceleration are plotted against landing trim in figure 15 for both configurations at the two gross loads and the various positions of the center of gravity. No landing instability was encountered, and the landings of both configurations were considered satisfactory. There appeared to be little difference in the landing behavior of the two configurations.

Spray characteristics.- The range of speed and gross load over which spray entered the propellers and struck the flaps is shown in figures 16 and 17. The corresponding trims and draft are plotted against speed in figures 18 and 19. Typical spray photographs are presented in figure 20 for the design gross load and the overload condition for both configurations.

Although spray entered the propellers for both configurations, this spray did not seem to impose any particular problem. The heavy bow blister was clear of the propellers except for a very short speed range. Spray on the flaps was not considered excessive, and the horizontal tail was generally clear. The round-keel configuration was the better of the two with regard to propeller spray because spray was in the propellers over a smaller speed range, and also with regard to flap spray, which was less severe for the round-keel configuration.

Rough-water landings.- Trim, horizontal, and vertical speeds, flight-path angle, and vertical and angular accelerations for the initial impact and the impact which resulted in the maximum acceleration during landing of the round-keel configuration at three landing trims in waves 4 feet high and 230 feet long are given in table II. Similar data at a trim of approximately 11° for wave lengths from 160 to 380 feet are presented in tables III to VI for the two configurations and wave heights of 6 and 8 feet.

The effect of landing trim on the rough-water behavior of the round-keel configuration is presented in figure 21. The rough-water landing characteristics during the initial impact (fig. 21(a)) did not appear to be influenced significantly by landing trim. The influence of landing trim at the impact for maximum vertical acceleration is shown in figure 21(b). At a landing trim of 4° the minimum trim was very low (negative) and the rise motions were very large. The condition of the model appeared to be so precarious that testing at 4° was discontinued without completing the schedule. At the 8° landing trim, this situation was improved. The accelerations, however, were somewhat larger than at 4°. At 12°, the behavior was in all respects better than that at 4° or 8°. In general, the landing behavior improved with increasing landing trim. Subsequent landing tests were therefore made at high trims.

The effect of wave-length—height ratio on rough-water landings is given in figures 22 and 23 for the two configurations. In general, the landing behavior became worse with decreasing length-height ratio. The usual peak beyond which a further decrease in length-height ratio would result in an improvement is not clearly defined by the data because waves with sufficiently small length-height ratios (below 24) could not be obtained. The round-keel configuration was slightly superior to the sharp-keel configuration with regard to minimum trim, especially at small length-height ratios but was slightly inferior with regard to maximum vertical acceleration. In general, the differences between the results for the two configurations were small.

CONCLUSIONS

The results of an investigation of the hydrodynamic characteristics of a 1/10-size powered dynamic model of the Martin M-267 patrol-type seaplane with two forebody configurations indicated the following conclusions:

1. Stable take-offs were possible with both configurations in smooth water for the aerodynamically practical range of positions of the center of gravity.

2. Landing stability in smooth water was satisfactory for both configurations.

3. The propellers and the flaps were clear of spray in smooth water for both configurations except over a very short speed range. The T-tail was generally clear of spray.

4. The rough-water landing behavior appeared to improve with increasing landing trim. In general, the differences in the rough-water landing characteristics of the two configurations were small.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
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TABLE I.- PERTINENT CHARACTERISTICS AND DIMENSIONS OF THE

MODEL AND THE FULL-SIZE SEAPLANE

	Model size	Full size
General:		
Design gross load, lb	[a]69.3	70,000
Overload condition, lb	[a]84.1	85,000
Wing area, sq ft	11.0	1,100
Overall length, ft	10.36	103.58
Hull:		
Overall length from auxiliary chine, ft	10.04	100.41
Forebody length from auxiliary chine, ft	4.53	45.28
Afterbody length, ft	5.51	55.13
Beam at chine at step, ft	0.72	7.15
Overall length-beam ratio	14.0	14.0
Forebody length-beam ratio	6.3	6.3
Afterbody length-beam ratio	7.7	7.7
Step:		
Type	60° V	60° V
Depth at keel, in.	0.025	0.25
Forebody dead rise at step (V cross section), deg	22.0	22.0
Angle between forebody and afterbody keel lines		
V-cross section, deg	9.0	9.0
Rounded cross section, deg	9.5	9.5
Wing:		
Area, sq ft	11.0	1,100
Span, ft	11.5	115
Root chord, ft	1.37	13.67
Tip chord, ft	0.55	5.47
Mean aerodynamic chord, ft	1.01	10.14
Aspect ratio	12.0	12.0
Taper ratio	2.5:1	2.5:1
Angle of incidence to sharp forebody keel		
Root, deg	4.0	4.0
Tip, deg	1.0	1.0
Flap deflection maximum, deg	45.0	45.0
Horizontal tail:		
Area, sq ft	2.4	240.0
Span, ft	3.41	34.1
Aspect ratio	4.85	4.85
Stabilizer deflection, deg	±12.0	±12.0
Elevator deflection, deg	±24.0	±24.0
Elevator-stabilizer deflection ratio	2:1	2:1
Vertical tail:		
Area, sq ft	1.67	167.0
Span, ft	1.38	13.8
Aspect ratio	1.15	1.15

[a]Specific weight of Langley tank no. 1 water in these tests was 63.4 lb/cu ft, as compared to 64.0 lb/cu ft for sea water.

TABLE II.- DATA OBTAINED DURING LANDINGS IN WAVES OF 4 FEET NOMINAL HEIGHT FOR THE ROUND-KEEL CONFIGURATION

[All values are model size]

Landing	Wave height, ft	Wave length, ft	Initial impact						Impact for maximum vertical acceleration						
			τ_L, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$	Impact	τ, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$
1	0.40	24.0	8.6	2.67	44.2	3.5	3.3	17	3	2.8	6.29	32.8	10.9	7.3	83
2	.37	23.8	8.4	2.40	44.0	3.1	2.6	12	1	8.4	2.40	44.0	3.1	2.6	12
2	.37	23.8	8.4	2.40	44.0	3.1	2.6	12	[a]4	8.0	3.56	24.3	8.3	2.3	30
3	.42	23.7	8.7	2.37	44.2	3.1	2.6	13	3	6.8	3.92	30.5	7.3	3.2	30
4	.37	23.4	8.5	2.61	44.5	3.4	3.5	23	3	2.0	6.65	33.0	11.4	7.5	98
5	.40	22.9	8.5	2.48	45.0	3.2	3.8	25	4	6.0	4.82	26.3	10.4	4.5	51
6	.42	22.5	8.2	2.62	45.8	3.3	3.1	22	6	7.2	4.39	26.8	9.3	3.4	40
7	.40	22.1	8.2	2.17	45.5	2.7	2.6	17	3	7.8	3.58	37.8	5.4	3.9	33
8	.42	22.2	8.2	2.52	45.3	3.3	4.0	23	3	3.7	5.37	34.5	8.8	5.4	52
9	.37	22.6	8.3	2.50	45.2	3.2	2.9	14	3	2.7	5.68	34.0	9.5	6.5	72
10	.37	20.8	12.0	2.28	45.2	2.9	2.8	27	2	10.2	4.78	37.0	7.4	3.8	17
11	.37	22.4	11.7	2.57	44.0	3.3	2.3	33	4	8.7	3.81	29.8	7.3	3.5	34
12	.40	22.0	12.2	2.84	42.8	3.8	3.2	30	2	9.0	4.20	34.8	6.9	4.7	32
13	.37	21.3	12.1	2.62	42.7	3.5	3.0	17	4	12.5	4.63	26.2	10.0	3.8	45
14	.37	22.6	12.0	2.90	42.3	3.9	3.7	33	2	5.6	4.01	35.3	6.5	4.1	50
15	.37	22.3	12.0	3.15	42.5	4.2	1.9	11	4	10.0	6.10	30.0	11.5	3.0	20
15	.37	22.3	12.0	3.15	42.5	4.2	1.9	11	[a]3	6.7	2.31	34.0	3.9	2.3	23
16	.37	22.1	12.0	2.95	42.2	4.0	3.4	20	1	12.0	2.95	42.2	4.0	3.4	20
16	.37	22.1	12.0	2.95	42.2	4.0	3.4	20	[a]4	7.5	4.11	25.6	9.1	3.2	37
17	.37	22.0	12.0	2.84	42.0	3.9	3.2	17	3	3.8	1.85	35.8	3.0	4.0	53
18	.40	22.5	4.0	2.25	49.6	2.6	4.1	25	4	5.5	4.57	30.6	8.5	4.6	50
18	.40	22.5	4.0	2.25	49.6	2.6	4.1	25	[a]3	-3.2	6.29	34.5	10.3	4.0	87
19	.37	23.7	4.0	2.42	50.0	2.8	3.6	24	3	4.5	6.32	36.0	10.0	6.2	61
19	.37	23.7	4.0	2.42	50.0	2.8	3.6	24	[a]4	-4.3	7.24	42.3	9.7	4.8	83
20	.37	22.2	4.0	2.36	49.4	2.7	3.0	13	3	0	6.26	35.2	10.1	5.0	50
21	.40	23.3	3.9	2.13	50.2	2.4	3.8	20	3	4	3.94	37.0	6.1	3.8	40
21	.40	23.3	3.9	2.13	50.2	2.4	3.8	20	[a]2	-.7	3.87	43.1	5.1	3.1	57

[a]Impact for maximum angular acceleration.

TABLE III.- DATA OBTAINED DURING LANDINGS IN WAVES OF 6 FEET NOMINAL HEIGHT

FOR THE ROUND-KEEL CONFIGURATION

[All values are model size]

Landing	Wave height, ft	Wave length, ft	Initial impact						Impact for maximum vertical acceleration						
			τ_L, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$	Impact	τ, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$
1	0.62	16.2	12.0	2.88	41.8	3.9	5.8	84	2	7.8	5.72	32.7	9.9	8.2	84
2	.62	16.0	12.0	2.68	42.2	3.6	4.7	27	3	5.5	3.60	32.3	6.4	5.4	62
3	.62	16.1	12.0	2.72	42.5	3.8	4.3	22	4	6.9	2.37	34.8	3.9	6.6	51
4	.58	15.7	12.0	2.96	42.2	4.0	3.9	46	3	5.0	4.95	29.2	9.6	8.2	116
5	.62	15.9	12.0	2.96	41.6	4.1	5.4	51	3	6.4	5.72	28.7	11.3	8.0	78
6	.62	15.8	12.0	2.76	42.8	3.7	4.6	30	3	6.3	4.96	31.1	9.1	7.9	92
7	.62	16.3	11.7	2.66	41.5	3.7	5.6	47	1	7.8	3.63	40.3	5.2	5.6	47
7	.62	16.3	11.7	2.66	41.5	3.7	5.6	47	[a]2	1.8	4.85	34.0	8.1	3.8	74
8	.62	15.8	11.7	2.73	41.9	3.7	5.6	57	2	4.0	5.44	34.7	8.9	7.1	96
9	.62	16.6	11.7	2.77	42.6	3.7	7.7	64	1	5.0	3.41	41.5	4.7	7.1	64
9	.62	16.6	11.7	2.77	42.6	3.7	7.7	64	[a]3	3.4	4.73	30.0	9.0	4.7	99
10	.62	19.6	12.0	2.87	43.0	3.8	6.9	80	2	8.3	8.12	33.4	13.7	10.0	116
11	.62	20.4	12.0	2.56	42.0	3.5	6.2	102	1	1.4	4.57	40.5	6.4	6.2	102
12	.62	20.0	11.9	2.61	42.9	3.5	5.5	42	3	3.4	3.36	31.0	6.1	9.8	141
13	.62	19.9	12.1	2.17	41.0	3.0	5.8	67	1	4.1	2.88	38.9	4.2	5.8	67
14	.62	19.6	9.8	3.24	42.0	4.4	8.1	84	2	6.5	3.65	32.6	6.4	8.9	88
15	.62	20.2	12.0	2.70	41.5	3.7	6.5	96	1	2.7	4.18	40.0	4.6	6.5	96
16	.62	19.3	12.0	2.52	42.7	3.4	4.3	24	5	8.1	5.03	24.3	11.7	5.8	57
17	.62	19.3	11.7	2.36	43.6	3.1	5.3	111	4	4.8	6.27	22.0	15.9	6.5	84
17	.62	19.3	11.7	2.36	43.6	3.1	5.3	111	[a]1	2.1	3.58	42.0	4.9	5.3	111
18	.58	21.1	11.8	3.00	42.3	4.1	6.2	28	1	11.3	3.43	41.0	4.7	6.2	28
18	.58	21.1	11.8	3.00	42.3	4.1	6.2	28	[a]6	3.8	5.30	21.7	13.8	4.5	88
19	.58	20.2	11.7	2.68	43.7	3.5	3.5	9	4	5.7	4.65	26.7	9.9	5.5	69
20	.58	20.1	11.7	2.68	43.5	3.5	4.5	69	4	6.0	4.94	21.8	12.8	4.9	63
21	.62	20.1	11.7	2.72	43.5	3.6	4.1	17	3	6.2	5.81	32.0	10.3	8.2	102
22	.58	20.9	11.8	2.91	42.1	4.0	3.1	9	4	9.0	4.18	26.9	8.8	5.3	56
23	.62	20.6	11.6	2.84	43.6	3.7	5.3	52	1	6.9	2.84	42.0	3.9	5.3	52
24	.62	20.9	11.0	2.76	46.5	3.4	4.6	90	1	3.1	2.76	41.1	3.9	4.6	90
25	.62	19.9	10.9	3.21	42.6	4.3	4.6	24	2	4.7	4.32	37.0	6.8	6.7	80
26	.62	20.8	10.9	2.55	44.0	3.3	4.7	89	1	3.7	2.55	42.3	3.5	4.7	89
27	.58	23.1	12.0	3.02	42.8	4.0	3.7	48	2	9.0	6.14	33.5	10.4	6.3	45
28	.58	23.7	12.0	2.82	41.5	3.9	3.8	44	2	10.1	6.56	32.4	11.5	6.5	50
29	.62	23.7	11.9	2.70	40.8	3.8	2.8	49	2	7.8	6.66	31.5	11.9	6.2	53
30	.62	23.9	11.8	2.85	42.0	3.9	4.4	48	3	7.6	6.39	33.0	11.0	6.2	55
31	.60	23.9	11.9	2.58	42.7	3.5	5.6	56	1	4.4	3.80	41.0	5.3	5.6	56
32	.62	23.6	11.9	2.92	41.7	4.0	3.3	51	2	7.8	6.97	32.5	12.1	7.0	65
33	.62	23.6	8.5	2.58	43.4	3.4	3.3	66	2	9.3	7.00	33.4	11.8	5.7	39
34	.62	24.0	11.5	2.58	43.0	3.4	4.8	51	4	7.6	5.24	26.9	11.0	4.9	48
35	.59	23.3	11.4	2.89	42.6	3.9	3.2	10	3	7.7	6.00	25.0	13.5	4.8	53
36	.62	23.6	11.4	2.61	42.2	3.5	4.3	7	4	8.9	5.59	25.3	12.5	4.6	41
37	.62	23.7	11.5	2.42	44.8	3.1	6.3	62	1	4.7	3.67	43.3	4.9	6.3	62
38	.62	23.8	8.7	3.42	42.0	4.7	4.0	32	4	6.4	5.28	25.0	11.9	5.3	57
39	.62	28.5	12.0	3.41	40.0	4.9	1.8	10	5	6.9	5.52	25.0	12.5	3.5	36
40	.62	27.6	12.0	3.18	41.1	4.4	3.3	4	5	7.2	4.94	26.7	10.5	4.0	48
41	.62	27.6	11.9	3.18	41.6	4.4	3.9	13	1	11.9	3.18	41.6	4.4	3.9	13
41	.62	27.6	11.9	3.18	41.6	4.4	3.9	13	[a]2	2.0	5.03	35.5	8.1	2.9	46
42	.60	27.4	11.9	2.69	42.0	3.7	4.1	57	2	5.7	6.52	32.3	11.4	7.8	88
43	.62	28.7	11.6	2.67	43.9	3.5	4.1	38	3	4.7	5.26	28.3	10.7	5.6	56
44	.60	27.4	11.4	2.88	43.2	3.8	5.4	61	2	6.2	5.92	33.7	10.0	7.8	74
45	.62	28.2	11.8	2.42	44.0	3.2	5.2	51	2	6.5	6.85	34.0	11.4	7.6	69
46	.62	29.1	11.5	2.90	42.5	3.9	3.7	34	4	6.3	5.34	27.0	11.2	6.6	70
47	.62	30.9	11.5	2.82	41.8	3.9	2.1	26	3	3.7	5.42	26.6	11.8	2.8	34
48	.62	31.6	11.0	2.92	42.0	4.0	2.4	10	5	2.5	5.95	26.2	12.8	4.0	47
49	.62	32.6	12.0	----	41.3	---	2.7	8	2	7.7	3.04	37.5	4.6	3.5	24
50	.58	32.7	12.0	2.82	42.5	3.8	3.3	29	1	4.1	2.95	39.5	4.3	3.3	29
51	.62	31.9	12.1	3.03	41.4	4.2	3.6	15	3	5.1	6.32	28.4	12.6	5.7	57
52	.62	32.6	12.1	3.12	41.2	4.3	3.5	28	3	2.8	5.30	28.0	10.7	3.8	43
53	.62	32.4	11.5	2.52	44.0	3.3	2.3	31	3	3.4	6.21	25.0	13.9	4.9	51
54	.62	30.2	11.6	2.83	42.8	3.9	2.4	34	3	3.2	7.28	27.0	15.1	5.9	64
55	.60	31.6	11.6	2.66	43.5	3.5	4.3	35	3	3.6	6.24	28.3	12.5	5.7	61

[a]Impact for maximum angular acceleration.

TABLE IV.- DATA OBTAINED DURING LANDINGS IN WAVES OF 8 FEET NOMINAL HEIGHT FOR THE ROUND-KEEL CONFIGURATION

[All values are model size]

Landing	Wave height, ft	Wave length, ft	Initial impact						Impact for maximum vertical acceleration						
			τ_L, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$	Impact	τ, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$
1	0.82	19.3	11.3	2.26	45.7	2.8	7.9	112	2	6.5	9.66	35.4	15.3	14.5	171
2	.82	19.8	11.4	2.04	46.4	2.5	9.0	---	2	9.7	5.76	36.7	8.9	9.4	---
3	.78	19.5	11.0	3.33	42.0	4.5	6.4	43	4	3.8	8.22	29.7	15.5	10.3	175
4	.78	19.1	11.4	----	42.8	---	9.0	83	2	2.3	-----	35.1	----	9.8	155
5	.82	20.4	11.4	3.07	43.1	4.1	2.9	11	3	4.3	5.08	34.0	8.2	8.0	109
6	.78	19.5	11.4	2.96	42.5	4.0	7.1	65	1	9.5	3.08	40.4	4.4	7.1	65
6	.78	19.5	11.4	2.96	42.5	4.0	7.1	65	[a]2	2.4	6.42	32.4	11.2	5.3	100
7	.78	20.2	11.3	2.78	44.5	3.6	5.8	40	2	1.6	8.74	35.2	14.0	8.4	132
8	.78	20.2	10.9	3.25	40.8	4.6	7.3	130	1	3.4	3.25	39.0	4.8	7.3	130
9	.82	22.2	10.5	2.41	43.5	3.2	7.2	52	1	10.4	2.96	42.0	4.2	7.2	52
9	.82	22.2	10.5	2.41	43.5	3.2	7.2	52	[a]4	1.7	4.28	27.5	8.8	4.7	136
10	.82	20.8	10.7	----	43.0	---	8.9	103	1	5.0	-----	41.2	----	8.9	103
11	.82	20.4	10.5	----	43.0	---	9.0	108	1	5.2	-----	42.1	----	9.0	108
12	.82	21.1	10.7	2.86	42.5	3.9	4.7	26	3	6.3	6.36	30.9	4.0	11.3	149
13	.78	20.1	11.0	2.48	43.3	3.3	8.4	88	1	7.7	2.84	42.0	3.9	8.4	88
14	.82	21.3	11.4	3.13	42.6	4.2	3.5	20	3	6.1	7.11	30.0	13.3	11.8	165
15	.82		10.3	2.28	44.0	3.0	7.2	92	2	.6	7.65	34.2	12.6	7.5	134
16	.82	20.6	11.5	2.34	44.5	3.0	6.8	116	1	4.4	2.52	42.5	3.4	6.8	116
17	.78	20.9	10.8	2.88	43.8	3.8	7.4	66	3	6.3	11.08	28.2	21.4	9.6	163
18	.78	20.9	11.1	2.47	44.0	3.2	5.8	72	3	10.7	2.38	32.8	4.2	5.8	72
18	.78	20.9	11.1	2.47	44.0	3.2	5.8	72	[a]1	3.5	2.91	42.5	3.9	5.4	118
19	.82	22.4	11.2	3.06	42.0	4.2	6.4	126	2	8.4	6.89	33.0	11.8	7.9	96
19	.82	22.4	11.2	3.06	42.0	4.2	6.4	126	[a]1	2.9	3.46	40.0	4.9	6.4	126
20	.78	23.4	11.2	2.47	43.5	3.2	6.2	101	1	1.4	4.30	41.8	5.9	6.2	101
21	.82	22.5	11.4	2.50	43.5	3.3	5.0	35	6	1.5	7.21	21.3	18.7	5.8	90
22	.80	23.1	11.3	2.58	44.0	3.4	7.1	114	1	2.0	4.53	42.5	6.1	7.1	114
23	.82	22.9	11.2	2.66	44.0	3.5	8.1	82	1	4.8	3.71	42.6	5.0	8.1	82
24	.78	23.4	11.0	2.51	43.5	3.3	5.1	52	4	2.4	7.58	21.2	19.7	6.6	113
25	.78	22.6	11.1	2.75	42.8	3.7	5.8	70	2	4.8	4.23	32.3	7.5	9.7	120
26	.82	23.6	11.3	3.18	42.0	4.3	5.3	56	3	2.3	7.95	29.6	15.0	9.8	123
27	.78	23.5	11.3	2.52	43.8	3.3	6.6	50	1	10.7	3.18	42.2	4.3	6.6	50
27	.78	23.5	11.3	2.52	43.8	3.3	6.6	50	[a]4	0	6.05	21.0	16.1	4.5	97
28	.78	23.8	10.9	2.69	42.9	3.6	5.3	24	2	4.9	5.62	34.6	9.2	8.3	87
29	.82	28.2	11.2	2.34	44.6	3.0	4.7	55	2	6.0	7.92	35.6	12.6	8.8	94
30	.82	28.7	11.2	3.06	41.9	4.2	4.5	18	2	1.9	4.19	34.8	6.9	7.3	104
31	.82	27.8	11.2	2.31	44.5	3.0	5.2	84	2	8.4	8.88	33.5	14.9	8.4	85
32	.82	28.2	11.3	2.57	44.2	3.3	6.6	69	2	7.0	9.64	34.2	15.8	7.1	74
33	.78	27.8	11.4	2.72	43.2	3.6	4.7	26	2	4.9	6.38	34.2	10.6	6.3	68
34	.82	28.7	11.5	2.73	41.6	3.8	4.4	26	2	6.0	4.00	27.2	8.4	8.6	92
35	.78	28.3	11.2	2.64	43.9	3.5	5.0	46	2	2.2	6.65	28.1	3.3	8.5	125
36	.78	28.7	11.1	2.83	42.8	3.8	6.2	69	2	.6	4.51	33.5	7.7	8.9	160
37	.82	28.7	11.0	2.73	42.5	3.7	4.3	63	2	2.8	9.68	33.2	16.3	9.0	102
38	.78	33.1	11.7	3.18	43.8	4.2	4.0	26	3	6.2	7.40	27.9	14.8	8.1	96
39	.82	32.0	11.7	2.52	44.5	3.2	2.3	7	4	5.0	6.47	27.8	13.1	7.9	85
40	.82	32.9	11.7	2.20	45.4	2.8	4.8	40	2	7.5	7.02	35.2	11.3	8.2	86
41	.82	33.0	11.7	1.94	43.0	2.6	4.1	7	3	7.1	7.38	29.8	13.9	5.6	48
42	.80	32.0	11.8	2.26	44.3	2.9	4.3	33	3	7.9	7.03	29.2	13.6	5.6	55
43	.80	33.0	11.3	2.47	43.8	3.2	4.2	47	3	5.3	6.04	24.8	13.7	7.9	87
44	.82	32.4	11.1	2.56	44.0	3.3	5.2	33	2	2.2	5.94	36.3	9.3	7.3	113
45	.82	31.9	10.9	2.59	43.3	3.4	5.3	37	3	1.5	7.40	35.4	11.8	8.2	131
46	.82	37.7	11.3	2.20	43.6	3.2	2.4	35	3	2.0	5.73	26.5	12.7	3.0	39
47	.82	35.9	11.2	2.96	42.9	4.0	3.8	10	3	2.7	5.20	28.6	10.3	5.9	64
48	.82	35.2	11.2	2.41	44.1	3.1	3.7	32	1	1.7	4.72	42.3	6.4	3.7	32
49	.78	36.4	11.8	2.57	43.1	3.4	3.2	9	4	7.1	5.08	29.5	9.8	5.0	48
50	.80	37.9	11.6	2.84	42.0	3.9	4.0	7	3	5.2	6.86	27.2	14.2	8.1	91
51	.78	38.1	11.7	2.49	43.1	3.4	4.2	45	1	3.9	4.75	41.0	6.6	4.2	45
52	.82	35.3	11.7	2.57	43.5	3.4	3.5	28	3	1.3	3.96	27.5	8.2	5.9	100
53	.78	36.2	11.6	2.49	42.8	3.3	3.0	7	5	5.0	6.43	24.7	14.6	5.3	69
54	.78	37.5	11.6	2.44	44.0	3.2	4.7	50	1	3.7	5.11	42.0	6.9	4.7	50

[a]Impact for maximum angular acceleration.

TABLE V.- DATA OBTAINED DURING LANDINGS IN WAVES OF 6 FEET NOMINAL HEIGHT

FOR THE SHARP KEEL CONFIGURATION

[All values are model size]

Landing	Wave height, ft	Wave length, ft	Initial impact						Impact for maximum vertical acceleration						
			τ_L, deg	V_s, fps	V, fps	γ, deg	n_V, g	α, $\frac{\text{radians}}{\text{sec}^2}$	Impact	τ, deg	V_s, fps	V, fps	γ, deg	n_V, g	α, $\frac{\text{radians}}{\text{sec}^2}$
1	0.58	16.1	11.8	----	41.1	---	6.3	102	2	6.1	----	33.3	----	6.8	105
2	.60	16.0	11.9	----	41.9	---	6.4	43	3	6.3	----	29.3	----	8.8	116
3	.62	15.7	11.9	----	41.0	---	5.6	77	3	5.1	----	27.9	----	5.7	129
4	.60	15.6	11.9	----	42.6	---	4.3	21	3	6.4	----	32.2	----	6.9	95
5	.62	15.7	10.2	2.64	44.0	3.4	5.3	71	2	7.3	4.82	36.1	7.5	8.8	135
6	.58	15.9	10.2	2.96	43.0	3.9	5.3	77	2	6.7	4.80	35.0	7.7	6.9	94
7	.62	16.4	10.2	2.44	45.1	3.1	5.8	39	2	4.9	4.44	38.1	6.6	6.9	100
8	.62	15.0	10.4	2.56	44.8	3.3	6.9	94	2	3.4	4.56	38.0	6.8	7.2	96
9	.62	15.3	10.2	2.68	44.9	3.4	5.1	48	2	4.0	3.82	38.3	5.6	7.5	95
10	.62	15.4	10.3	2.40	45.0	3.0	6.4	85	1	6.0	2.40	43.3	3.1	6.4	85
10	.62	15.4	10.3	2.40	45.0	3.0	6.4	85	[a]3	3.4	5.68	31.6	10.1	5.1	91
11	.58	15.7	10.1	2.67	45.0	3.4	6.3	85	3	4.4	5.25	30.3	9.6	7.5	119
12	.62	16.0	10.0	2.51	45.1	3.1	5.7	80	3	5.8	4.40	31.8	7.8	7.6	92
13	.58	16.7	10.2	2.52	44.8	3.2	3.3	23	2	4.5	3.19	39.6	4.5	5.6	85
14	.58	16.3	10.2	2.54	45.3	3.2	8.0	95	3	4.8	5.34	31.1	9.5	8.3	134
15	.62	15.4	10.3	2.23	46.2	2.7	5.9	80	1	5.2	2.23	45.1	2.8	5.9	80
16	.62	17.8	10.1	2.20	45.0	2.8	4.8	36	2	1.2	5.44	38.0	8.0	4.8	70
17	.62	18.1	10.2	1.82	47.0	2.2	3.0	19	4	5.4	5.97	32.3	10.3	7.1	123
18	.62	16.7	10.7	2.89	43.6	3.8	7.2	106	1	4.5	3.42	42.2	4.6	7.2	106
19	.58	17.7	10.7	2.36	46.0	2.9	3.6	6	2	5.9	2.58	40.7	3.6	5.3	74
20	.62	17.0	10.7	2.51	45.4	3.2	6.3	95	1	5.0	3.06	44.1	4.0	6.3	95
21	.58	17.7	10.7	2.30	45.9	2.9	5.1	63	2	6.8	4.74	38.0	7.1	8.8	123
22	.62	17.7	10.7	----	46.0	---	6.6	77	2	5.6	----	38.1	----	8.6	138
23	.58	18.7	10.7	2.34	45.9	2.9	6.0	95	2	8.5	5.40	36.5	8.4	6.9	62
23	.58	18.7	10.7	2.34	45.9	2.9	6.0	95	[a]1	2.5	2.94	43.8	3.8	6.0	95
24	.58	18.1	10.7	2.36	45.7	3.0	4.7	52	2	4.1	4.56	38.1	6.8	5.7	94
25	.62	19.7	12.2	2.88	41.0	4.0	4.0	37	2	3.2	4.85	33.8	8.2	4.5	87
26	.58	19.6	12.2	2.76	41.0	3.9	3.2	19	2	6.7	3.10	33.5	5.3	3.7	43
27	.58	19.7	12.1	2.52	42.1	3.4	5.3	57	1	5.6	3.49	40.7	4.9	5.3	57
28	.58	19.0	11.1	1.80	42.4	2.4	4.7	31	4	6.3	4.19	23.8	10.0	5.5	79
29	.60	19.9	11.1	2.88	40.9	4.0	4.6	28	3	4.0	5.05	30.9	9.3	5.4	90
30	.60	19.0	11.1	2.66	42.2	3.6	5.5	56	2	5.4	5.54	33.2	9.5	6.2	100
31	.62	19.0	11.3	2.79	41.0	3.9	3.4	21	3	6.2	5.51	31.0	10.1	6.7	105
32	.60	19.5	11.1	2.61	41.6	3.6	4.1	75	4	3.0	4.14	21.5	10.9	4.1	77
33	.60	23.6	12.2	2.32	42.2	3.2	5.3	61	2	9.4	5.40	34.3	9.0	5.5	54
34	.62	23.1	12.1	2.80	40.0	4.0	3.6	7	2	5.2	3.44	34.6	5.7	3.9	38
35	.62	23.6	12.1	2.46	42.6	3.3	4.0	34	2	2.7	5.66	34.7	9.3	5.2	89
36	.62	23.1	12.1	2.64	41.0	3.7	3.2	39	2	8.6	6.28	32.0	11.1	6.0	64
37	.62	23.4	11.2	2.69	41.0	3.8	4.2	30	4	9.1	4.94	24.0	11.6	5.7	55
38	.62	23.4	11.3	2.87	41.6	4.0	3.9	19	4	8.4	5.14	24.2	12.0	4.4	48
39	.58	23.4	11.1	2.68	40.9	3.8	4.4	25	2	4.0	4.81	34.6	7.9	6.4	89
40	.62	22.6	11.1	1.82	41.5	2.5	4.2	42	1	7.9	3.41	40.0	4.9	4.2	42
41	.62	28.0	11.9	----	42.0	---	3.4	30	3	6.6	----	27.3	----	5.7	70
42	.62	28.0	12.1	----	42.3	---	3.7	29	3	6.7	----	27.6	----	5.3	70
43	.62	28.7	11.9	----	40.8	---	2.9	9	4	9.0	----	29.8	----	3.7	38
44	.58	27.4	11.4	2.59	43.0	3.5	1.9	34	2	7.0	6.96	32.8	12.0	5.6	66
45	.62	29.1	11.4	2.60	43.0	3.5	2.5	5	3	9.2	2.95	36.0	4.7	3.1	26
46	.62	28.7	11.4	2.56	42.7	3.4	3.1	28	3	5.2	6.00	27.1	12.5	4.8	59
47	.62	29.6	11.2	2.96	42.2	4.0	3.5	21	2	6.4	5.27	34.9	8.6	4.9	62
48	.60	29.9	11.4	2.44	42.7	3.3	3.6	36	3	8.1	5.92	27.1	12.3	5.0	61
49	.62	29.1	11.2	2.72	42.1	3.7	2.6	7	5	8.2	4.88	26.7	10.4	4.0	44
50	.62	32.2	11.4	2.57	42.7	3.6	2.5	25	3	6.0	5.87	26.4	12.5	4.1	46
51	.58	31.4	11.4	2.79	42.1	3.8	3.0	18	3	4.1	5.60	27.9	11.4	4.2	56
52	.60	31.0	12.0	----	43.0	---	3.5	45	3	5.7	----	27.9	----	5.0	66
53	.60	31.6	12.0	----	42.8	---	3.2	9	3	8.1	----	30.0	----	4.2	45
54	.62	29.9	12.0	----	43.2	---	3.2	30	3	6.5	----	28.7	----	4.7	54
55	.62	33.0	11.4	2.65	43.0	3.5	2.3	30	3	5.7	5.56	27.5	11.4	4.1	50
56	.58	33.9	11.4	2.53	43.9	3.3	2.6	23	3	5.2	5.16	27.5	10.6	2.4	32
57	.60	31.0	11.4	2.40	43.6	3.2	3.2	24	3	6.2	6.06	27.9	12.3	4.8	47
58	.62	32.2	11.4	2.46	43.0	3.3	2.3	23	3	3.0	5.16	27.6	10.6	2.3	36
59	.60	31.2	11.4	2.57	43.0	3.4	2.9	9	3	8.0	5.09	30.0	9.6	4.7	50
60	.62	34.1	11.4	2.56	43.2	3.4	2.6	5	5	6.9	5.04	26.8	10.7	3.5	43
61	.60	31.4	11.4	2.90	43.0	3.9	3.1	18	3	4.6	5.48	28.2	11.0	4.6	59
62	.62	32.6	11.5	2.57	43.0	3.4	2.2	7	5	7.5	5.42	27.0	11.4	3.7	39

[a]Impact for maximum angular acceleration.

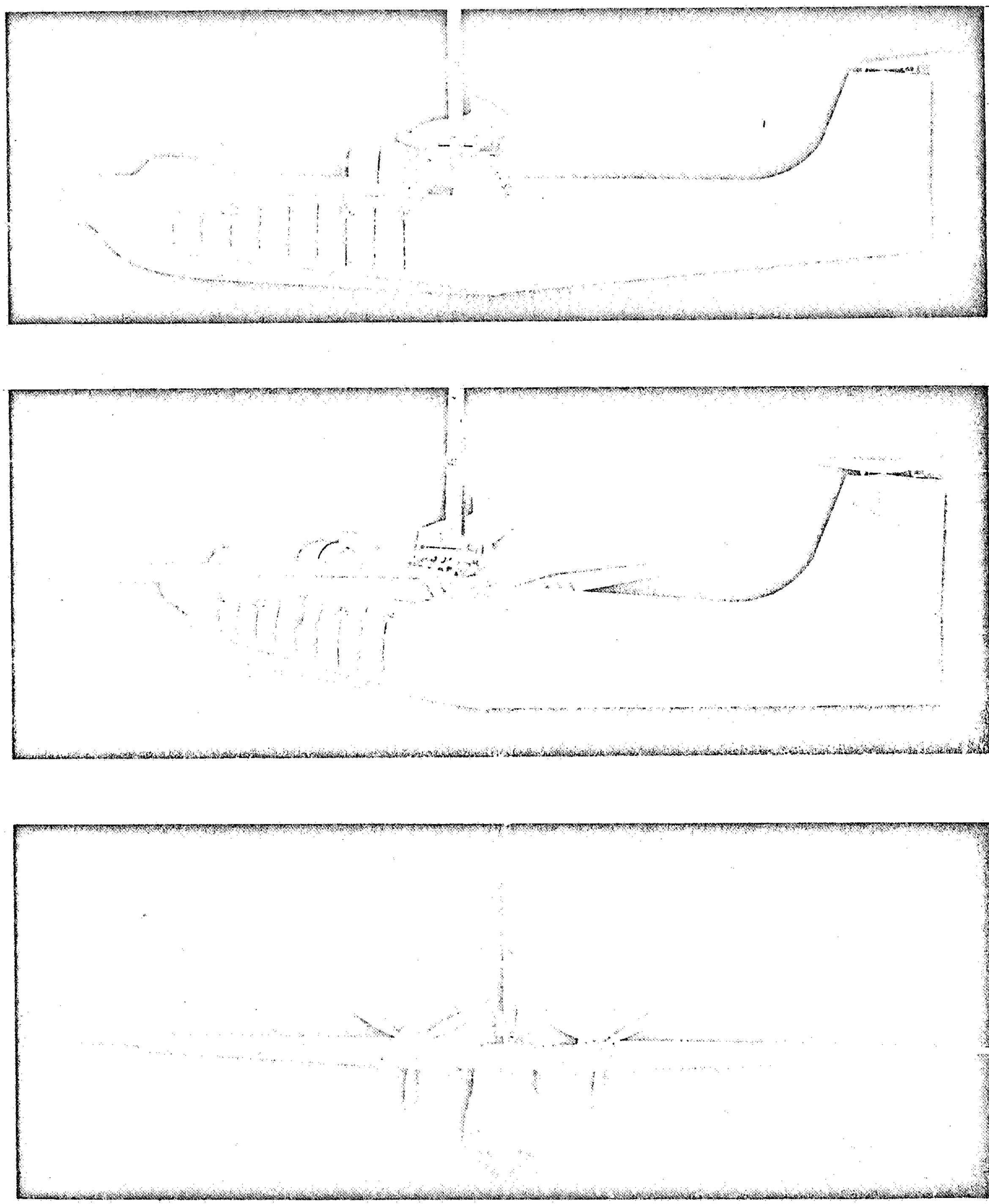
TABLE VI.- DATA OBTAINED DURING LANDINGS IN WAVES OF 8 FEET NOMINAL HEIGHT

FOR THE SHARP-KEEL CONFIGURATION

[All values are model size]

Landing	Wave height, ft	Wave length, ft	Initial impact						Impact for maximum vertical acceleration						
			τ_L, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$	Impact	τ, deg	V_s, fps	V, fps	γ, deg	n_v, g	α, $\frac{\text{radians}}{\text{sec}^2}$
1	0.78	20.7	11.8	2.81	42.3	3.8	6.4	34	2	7.5	4.15	35.6	6.7	8.4	62
1	.78	20.7	11.8	2.81	42.3	3.8	6.4	34	[a]3	3.2	4.47	30.5	8.3	6.3	108
2	.78	20.4	11.9	3.06	41.3	4.2	7.1	127	2	3.2	8.21	31.5	14.6	7.4	170
3	.78	18.7	11.8	2.96	41.5	4.1	7.2	46	1	11.8	7.96	41.5	4.1	7.2	46
3	.78	18.7	11.8	2.96	41.5	4.1	7.2	46	[a]2	2.7	6.33	33.0	10.9	5.4	99
4	.82	20.1	10.5	2.62	44.6	3.4	5.7	42	5	6.5	4.63	23.7	11.1	6.1	106
5	.82	20.5	10.5	2.50	45.1	3.2	3.6	92	2	7.9	6.96	36.0	10.9	10.0	113
6	.78	19.6	10.4	2.79	45.0	3.6	4.2	121	2	6.5	7.84	35.5	12.5	12.0	194
7	.78	20.1	10.4	2.67	44.9	3.4	7.0	51	3	.9	6.89	30.1	12.9	7.4	148
8	.82	20.4	10.4	2.71	44.0	3.5	5.8	35	2	4.8	4.11	39.1	6.0	6.7	92
8	.82	20.4	10.4	2.71	44.0	3.5	5.8	35	[a]3	1.4	4.94	34.3	8.2	5.5	112
9	.78	20.4	10.4	2.35	46.0	2.9	8.2	56	2	6.6	6.44	36.9	9.9	8.5	86
9	.78	20.4	10.4	2.35	46.0	2.9	8.2	56	[a]7	2.0	5.33	20.8	14.4	4.1	110
10	.82	20.0	10.4	2.57	44.9	3.3	2.6	19	5	2.7	5.18	32.3	9.1	8.7	145
11	.78	20.8	10.4	2.48	45.7	3.1	7.0	63	2	3.6	6.42	37.1	9.8	10.0	126
12	.82	23.2	11.3	3.11	39.4	4.5	5.0	34	2	3.3	4.68	33.0	8.1	7.5	108
13	.78	23.6	11.5	3.05	39.2	4.5	5.3	28	2	5.3	5.09	33.0	8.8	7.5	108
14	.78	25.1	11.3	3.16	39.0	4.6	3.8	11	4	2.3	5.63	21.0	15.0	4.9	73
15	.78	23.5	11.3	3.10	39.8	4.5	4.8	62	2	8.2	5.92	31.0	10.8	7.4	69
16	.82	23.1	12.0	2.70	42.1	3.7	6.6	42	1	6.7	3.66	40.1	5.2	6.6	42
16	.82	23.1	12.0	2.70	42.1	3.7	6.6	42	[a]4	-.7	5.60	18.9	16.5	3.5	48
17	.78	23.8	11.9	3.24	40.9	4.5	3.7	19	2	2.2	5.52	35.2	8.9	6.5	115
18	.82	23.9	11.8	3.30	40.2	4.7	4.3	16	4	5.1	6.27	22.3	15.7	6.3	88
19	.78	23.8	11.8	3.06	41.0	4.3	5.6	66	2	2.9	6.90	32.3	12.1	7.3	122
20	.82	23.2	11.8	2.94	41.0	4.1	7.7	125	1	3.5	4.30	39.2	6.3	7.7	125
21	.78	28.8	11.4	3.08	40.8	4.3	2.9	0	4	5.3	5.12	25.2	11.5	6.1	87
22	.82	27.7	11.5	2.93	40.4	4.2	2.4	0	4	5.6	5.58	25.0	12.6	6.0	75
23	.78	28.7	11.5	2.88	41.1	4.0	2.5	0	4	10.1	5.80	25.9	12.6	6.6	68
24	.78	26.9	11.3	3.28	39.2	4.8	4.1	16	3	7.3	4.96	27.0	10.4	4.2	48
24	.78	26.9	11.3	3.28	39.2	4.8	4.1	16	[a]5	1.1	5.66	19.1	16.5	3.4	66
25	.78	27.7	11.3	2.82	39.7	4.1	2.3	36	3	8.3	5.81	24.2	13.5	7.5	94
26	.82	29.9	11.4	2.72	39.9	3.9	4.2	59	3	8.5	6.08	24.3	14.1	5.6	62
27	.78	29.1	12.0	3.24	41.0	4.5	4.9	19	2	3.3	6.57	33.9	11.0	7.7	116
28	.82	29.1	12.0	3.57	39.9	5.1	5.1	46	2	3.3	6.30	32.7	10.9	6.4	94
29	.78	28.7	12.0	2.92	41.0	4.1	4.0	71	2	7.0	8.15	31.0	14.7	7.2	81
30	.78	29.1	12.0	3.12	40.3	4.4	3.1	7	4	8.1	6.24	25.0	14.0	5.0	55
31	.78	32.6	11.3	3.02	40.0	4.3	4.1	23	3	6.3	5.24	26.4	11.2	6.2	63
32	.78	32.9	11.3	3.05	39.7	4.4	3.8	17	3	6.3	5.23	26.2	11.3	7.1	105
33	.78	31.4	11.3	3.17	40.0	4.5	2.9	3	4	7.2	5.12	27.8	10.4	5.3	60
34	.78	31.8	11.3	3.17	39.7	4.6	4.0	24	3	4.8	5.83	26.9	12.2	6.7	103
35	.78	33.6	11.3	2.43	43.0	3.2	5.0	43	3	6.8	6.37	27.0	13.3	6.8	70
36	.82	30.7	11.3	2.45	42.9	3.3	4.3	45	3	6.0	6.26	28.0	12.6	7.2	98
37	.78	32.4	12.0	2.74	41.0	3.8	4.3	68	3	4.1	5.85	24.8	13.3	5.2	68
38	.78	32.3	12.0	3.46	40.4	4.9	4.5	23	3	6.7	6.12	27.6	12.5	6.3	68
39	.82	31.5	12.0	3.18	40.3	4.5	3.8	11	3	4.9	6.40	27.3	13.2	7.7	123
40	.78	31.9	12.0	3.36	40.9	4.7	4.6	10	3	4.8	6.60	28.0	13.3	7.3	108
41	.82	32.9	12.0	2.88	41.2	4.0	4.2	52	3	6.7	6.20	24.6	14.1	6.0	77
42	.78	36.3	11.9	2.66	42.1	3.6	2.7	36	2	7.1	5.81	32.0	10.3	3.2	21
43	.78	37.4	11.5	2.79	42.5	3.8	2.7	30	3	4.0	6.12	25.1	13.7	3.3	43
44	.82	37.5	11.5	2.88	42.3	3.9	3.3	36	1	4.2	3.94	40.2	5.6	3.3	36
45	.78	37.4	11.4	2.49	43.6	3.3	3.3	25	3	2.5	6.35	27.8	12.9	5.4	81
46	.78	38.8	11.5	3.20	41.8	4.4	4.7	18	3	4.5	5.76	28.3	11.5	5.6	68
47	.78	33.4	11.4	2.80	41.8	3.8	3.0	5	2	10.2	2.66	37.9	4.0	4.6	36
48	.78	38.8	11.3	2.80	43.0	3.7	4.0	34	3	3.6	6.19	27.0	12.9	4.0	43
49	.78	37.0	11.5	2.40	42.0	3.3	4.0	35	4	4.8	6.29	24.8	14.2	4.4	59

[a]Impact for maximum angular acceleration.



L-83702

Figure 1.- 1/10-size model of Martin M-267 (sharp-keel configuration).

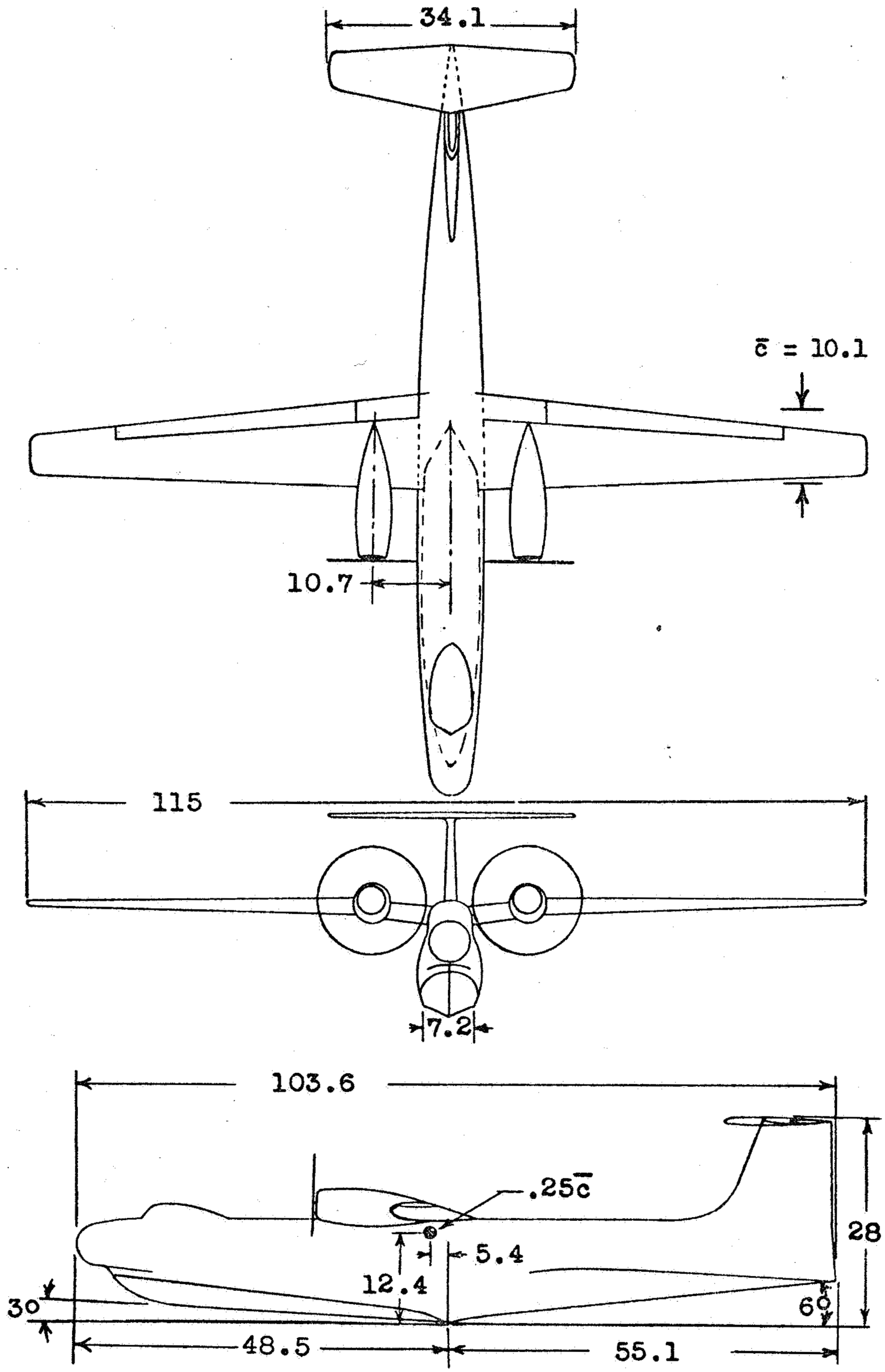


Figure 2.- General arrangement of sharp-keel configuration. (All dimensions are in feet, full size.)

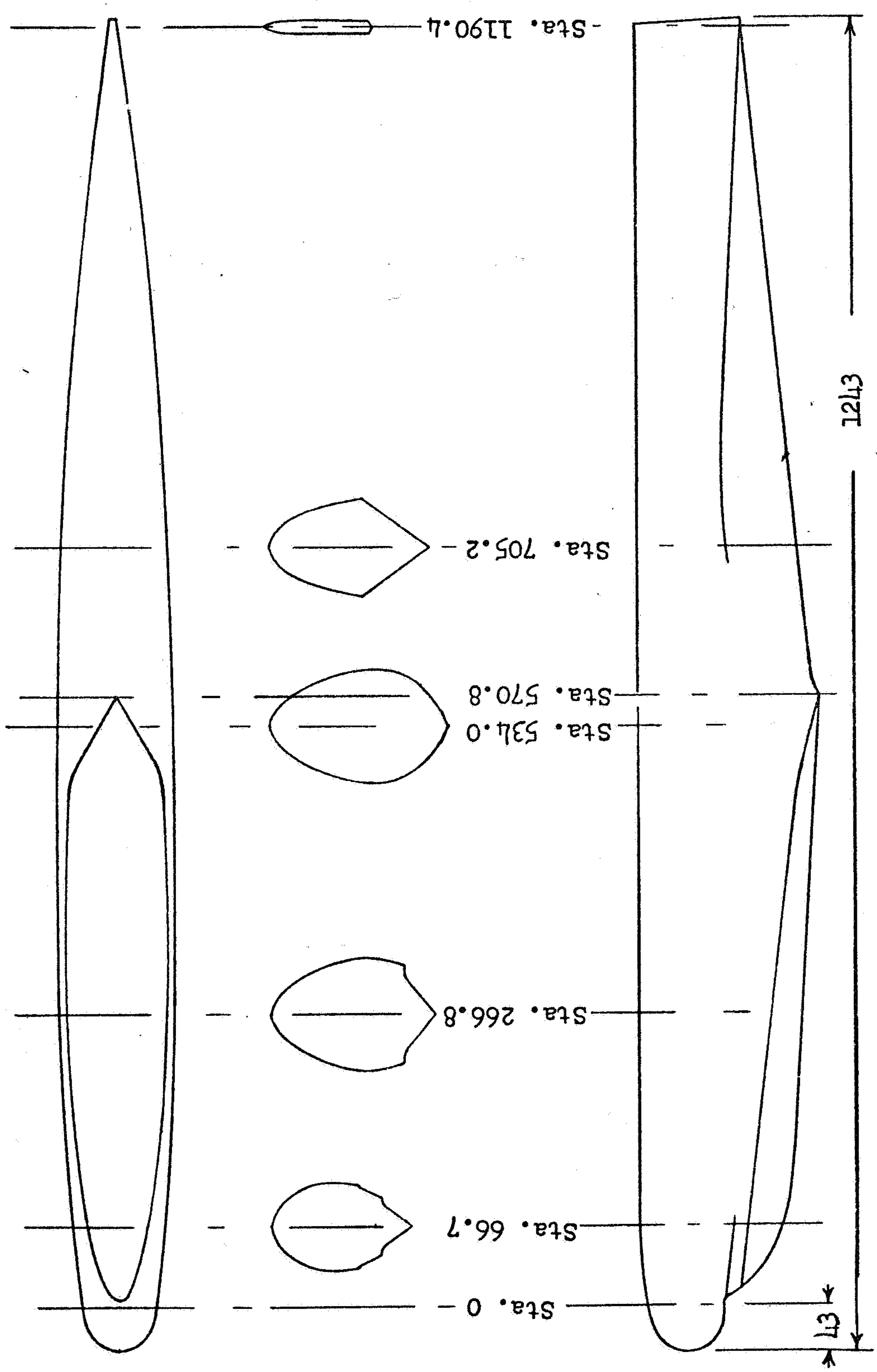


Figure 3.- Hull lines of sharp-keel configuration. (All dimensions are in inches, full size.)

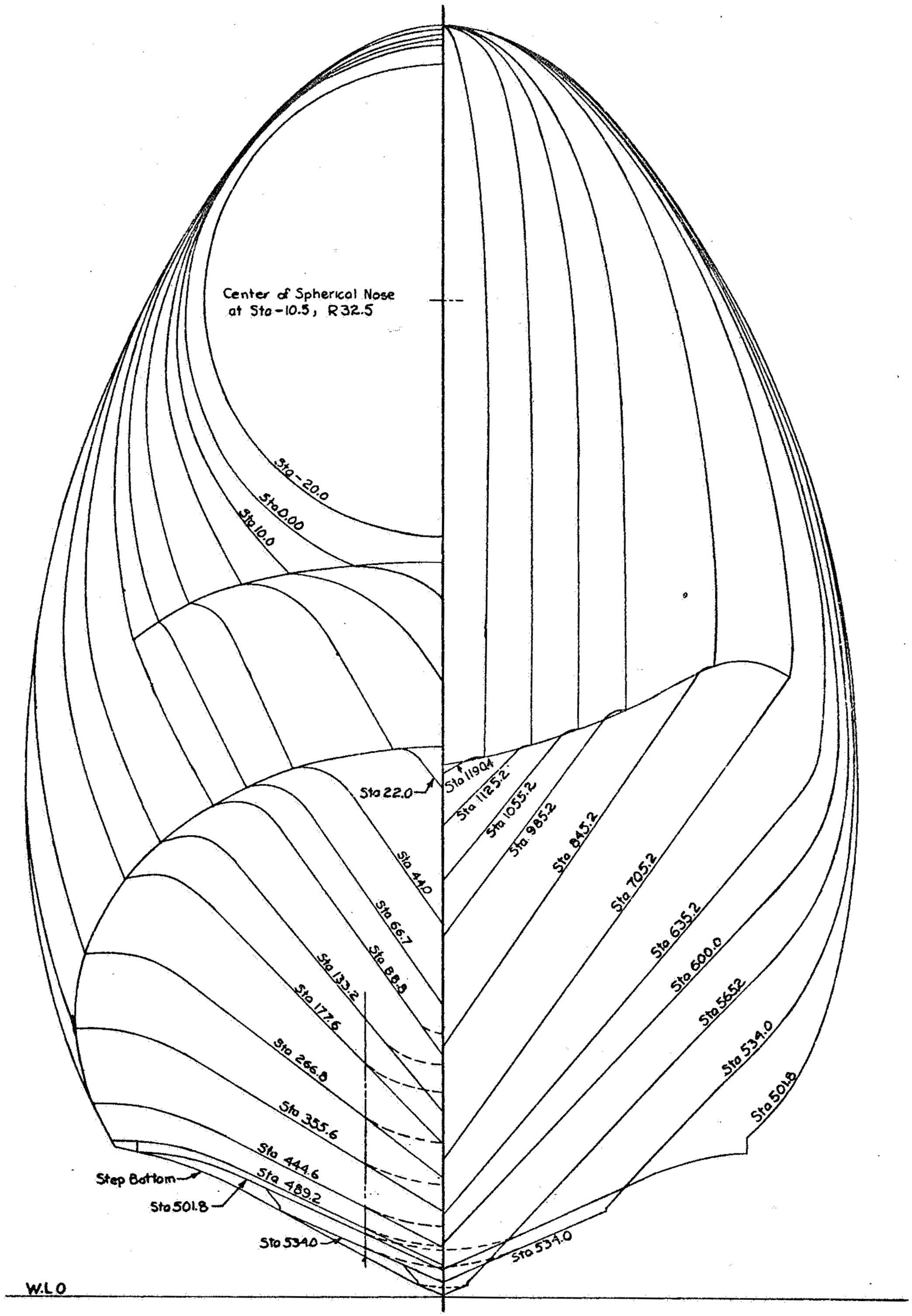
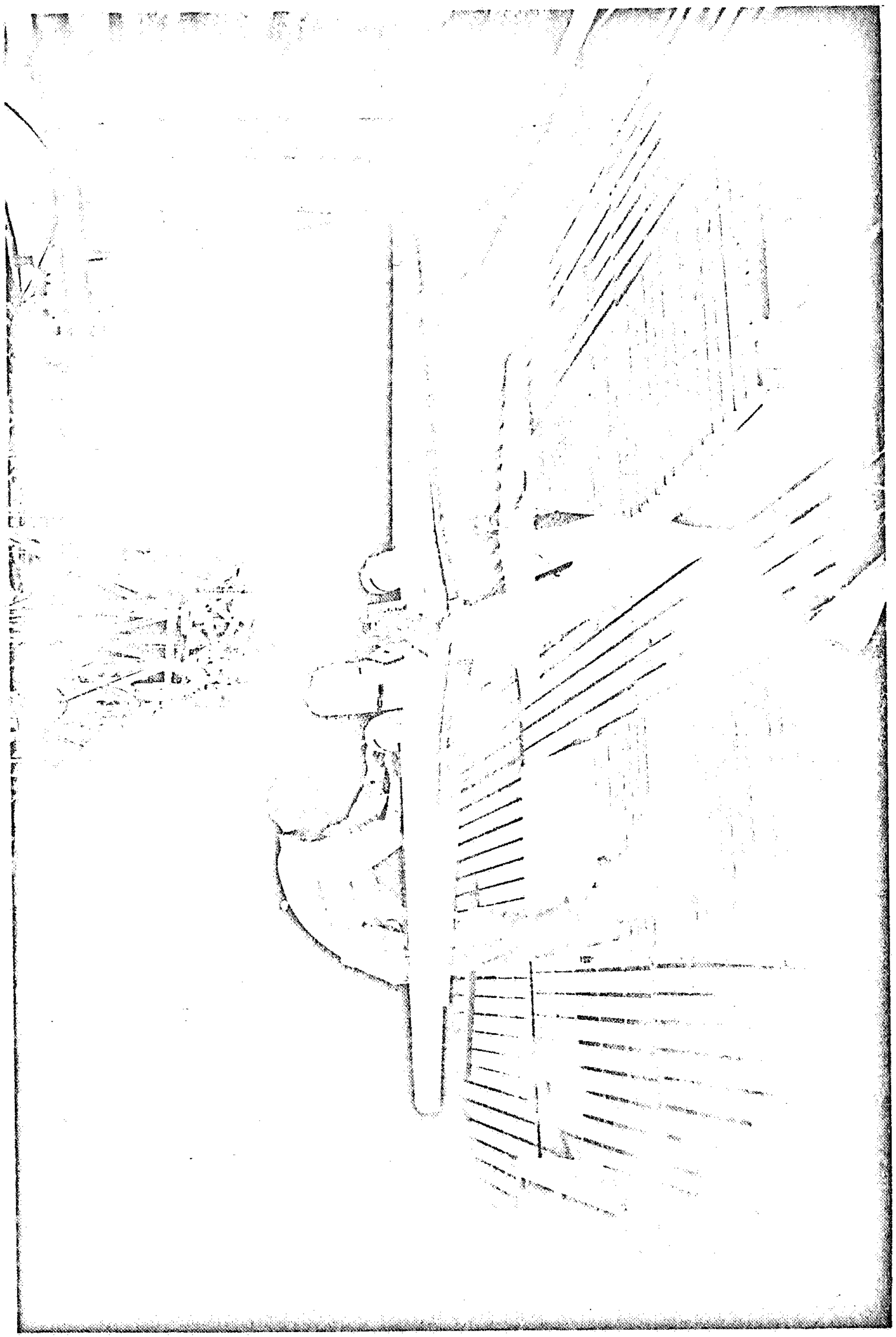


Figure 4.- Hull lines. (Dashed lines are changes in forebody sections to form the round-keel configuration. Station numbers are distances from station 0.00 in inches.)



L-78574.1

Figure 5.- Setup of model on towing apparatus.

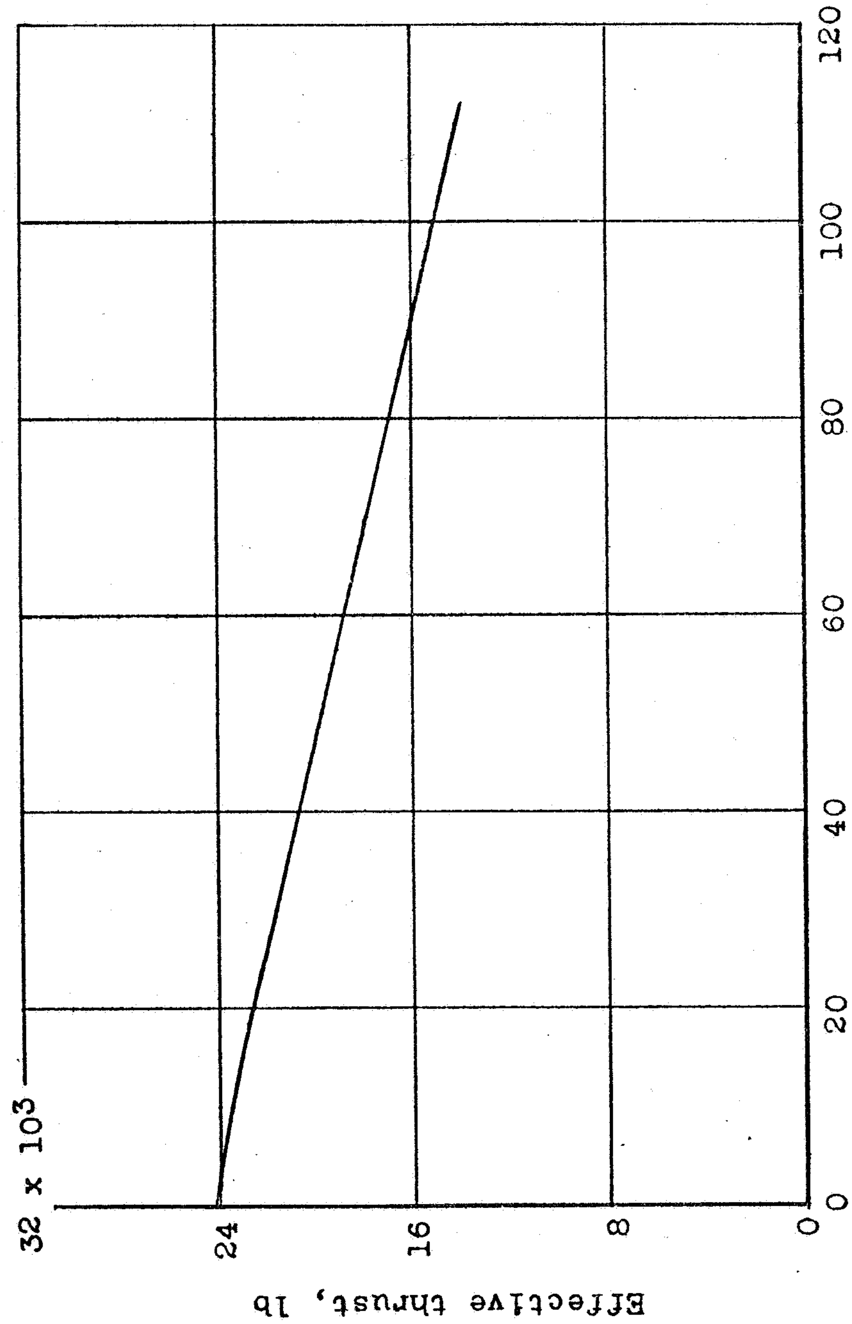


Figure 6.- Effective thrust. $\tau = 3^\circ$; $\delta_s = 0^\circ$; $\delta_f = 30^\circ$.

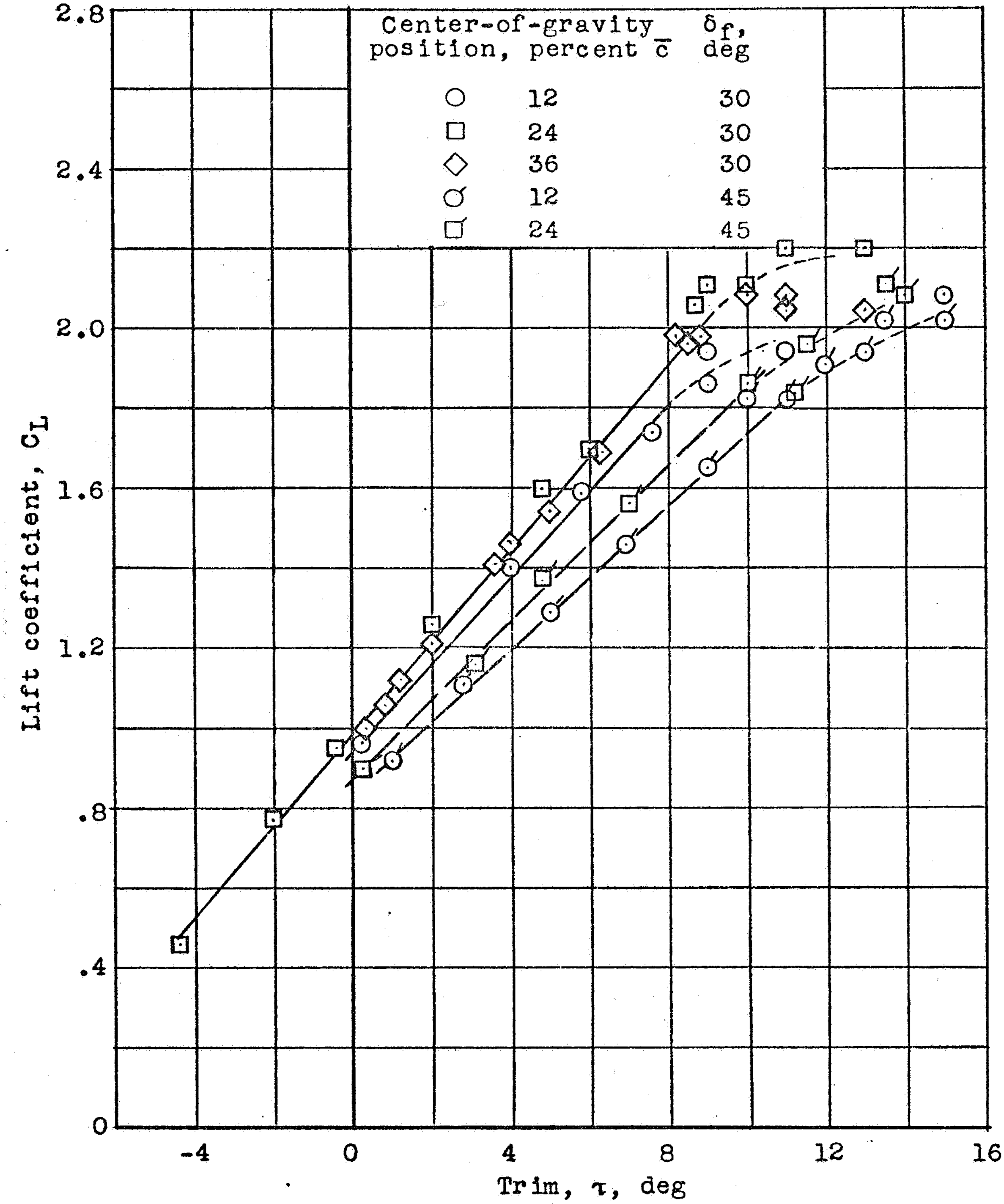
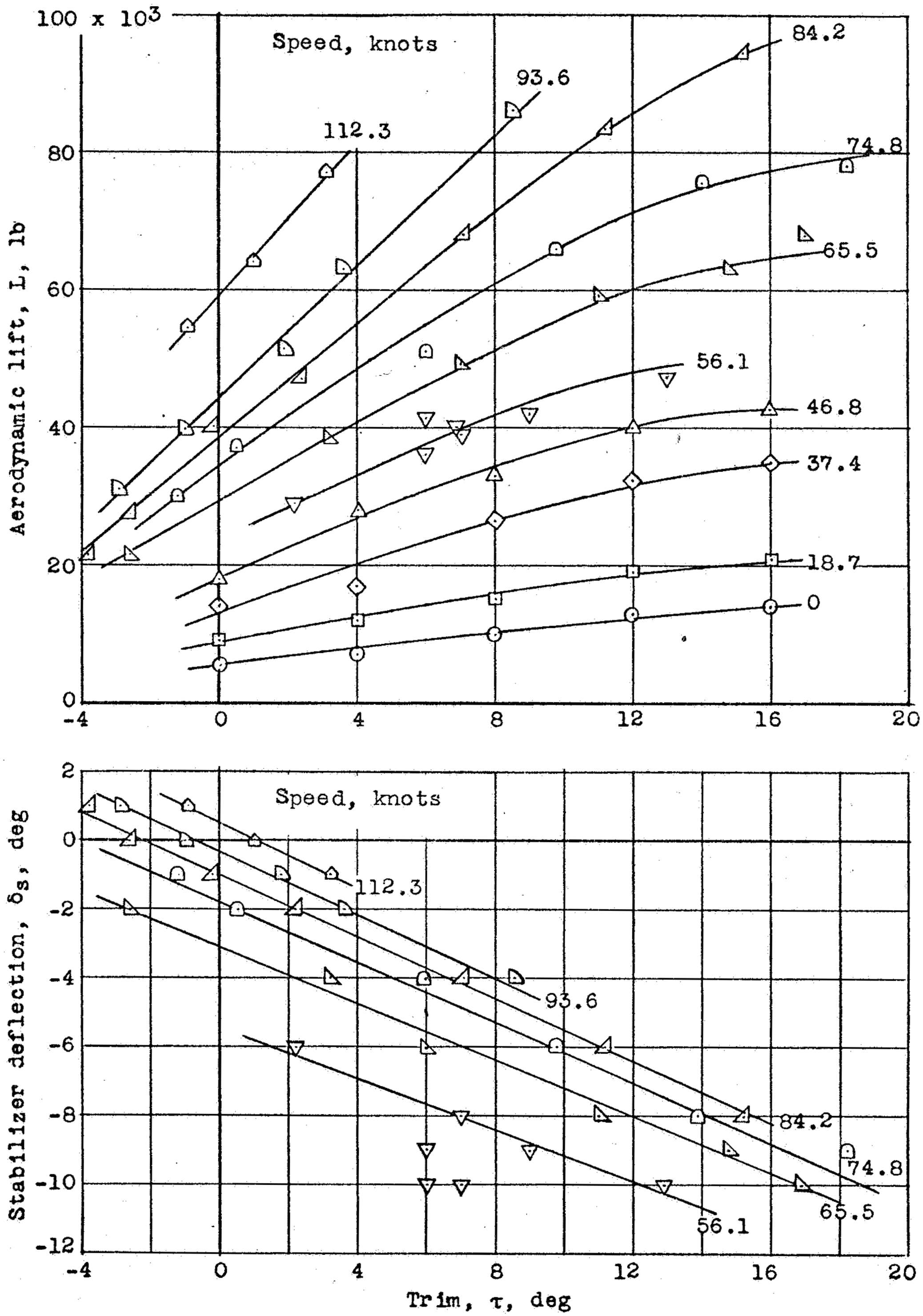
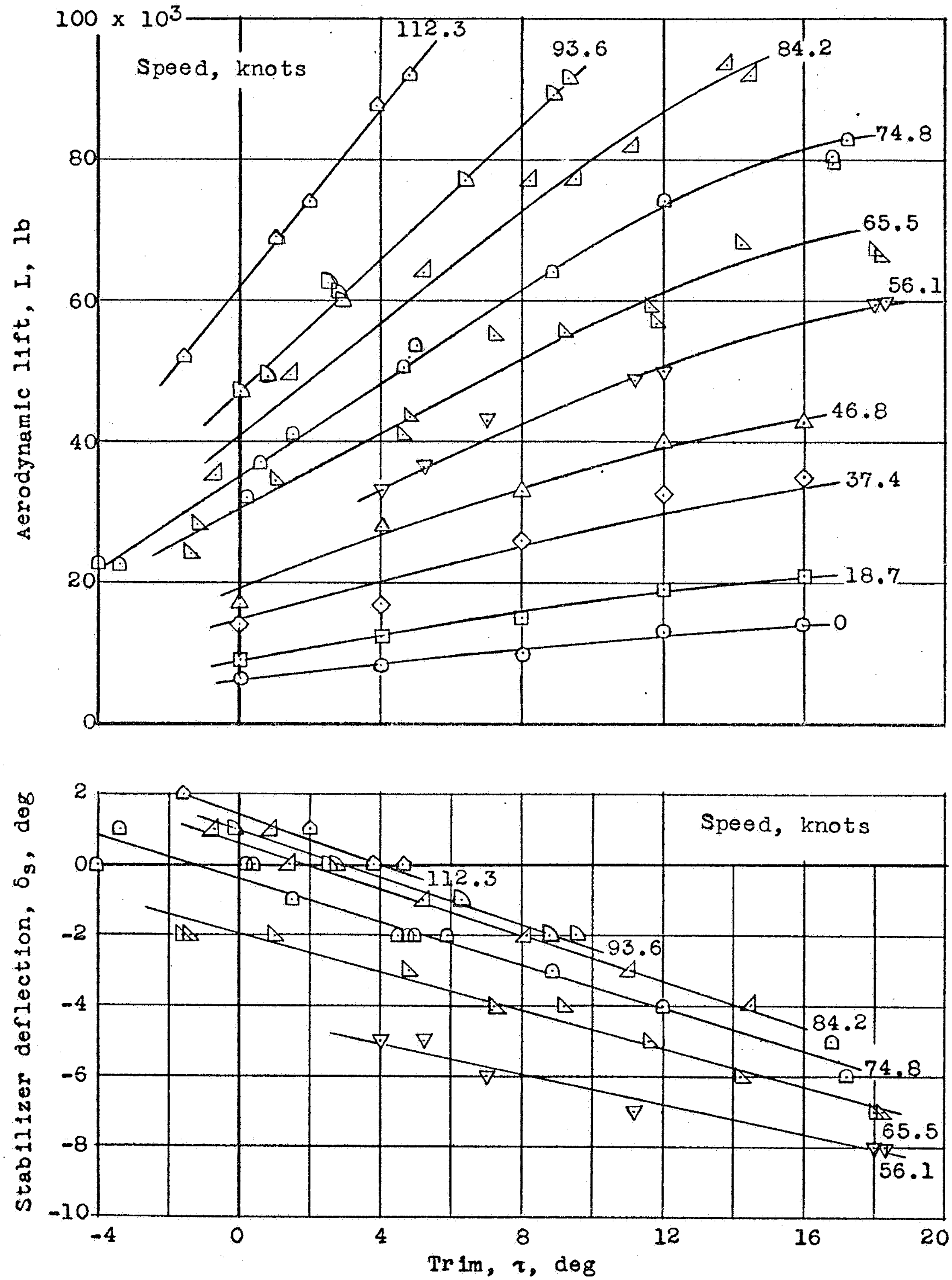


Figure 7.- Free-to-trim aerodynamic lift coefficient. Power off.



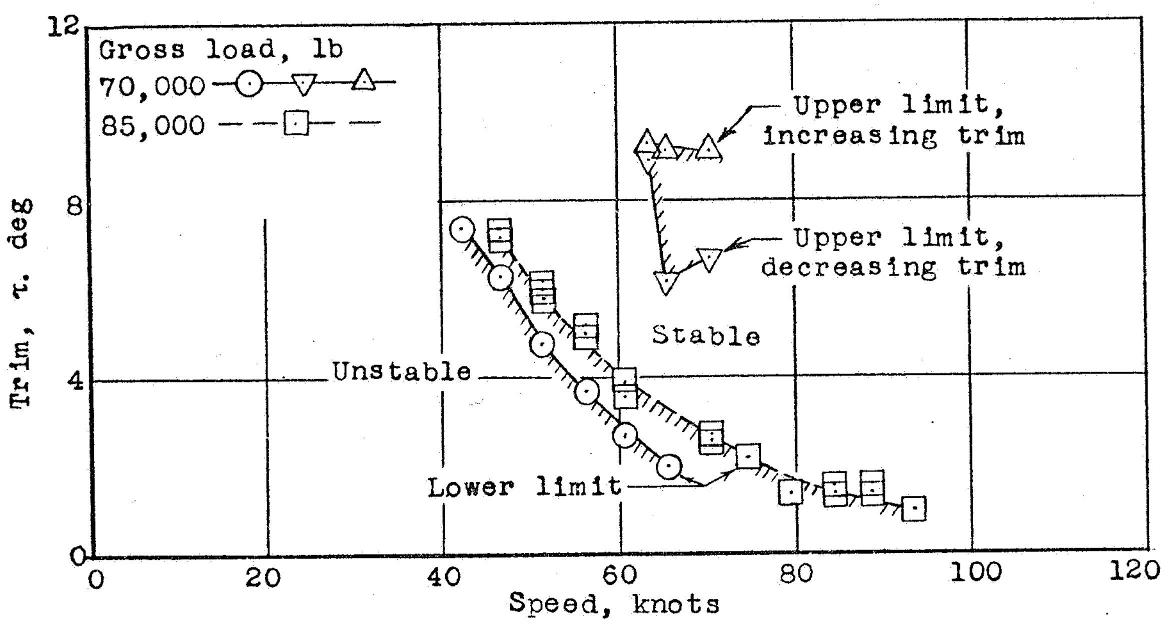
(a) Center-of-gravity position, $0.12\bar{c}$.

Figure 8.- Variation of aerodynamic lift and stabilizer deflection with trim. Power on; $\delta_f = 30^\circ$.

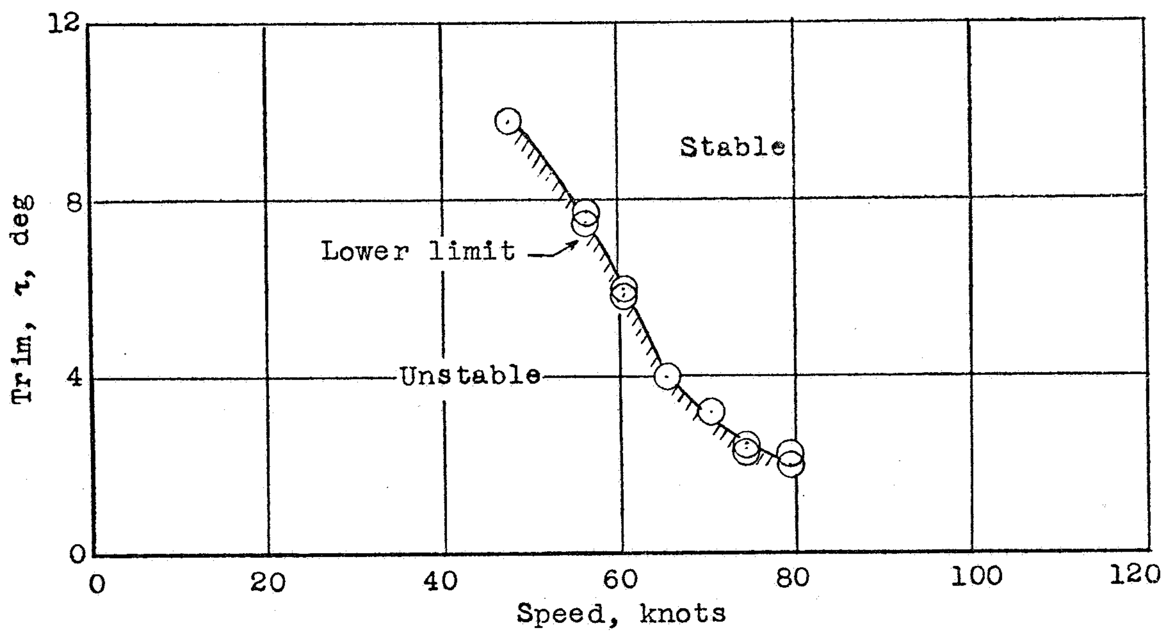


(b) Center-of-gravity position, 0.24$\bar{c}$.

Figure 8.- Concluded.

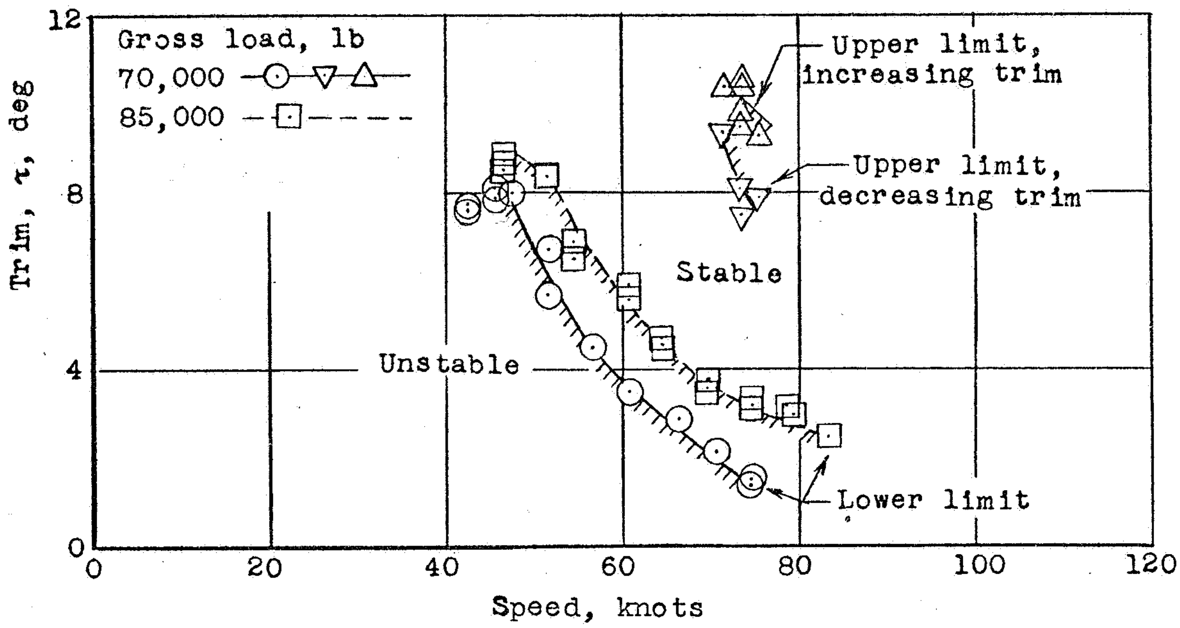


(a) Power on.

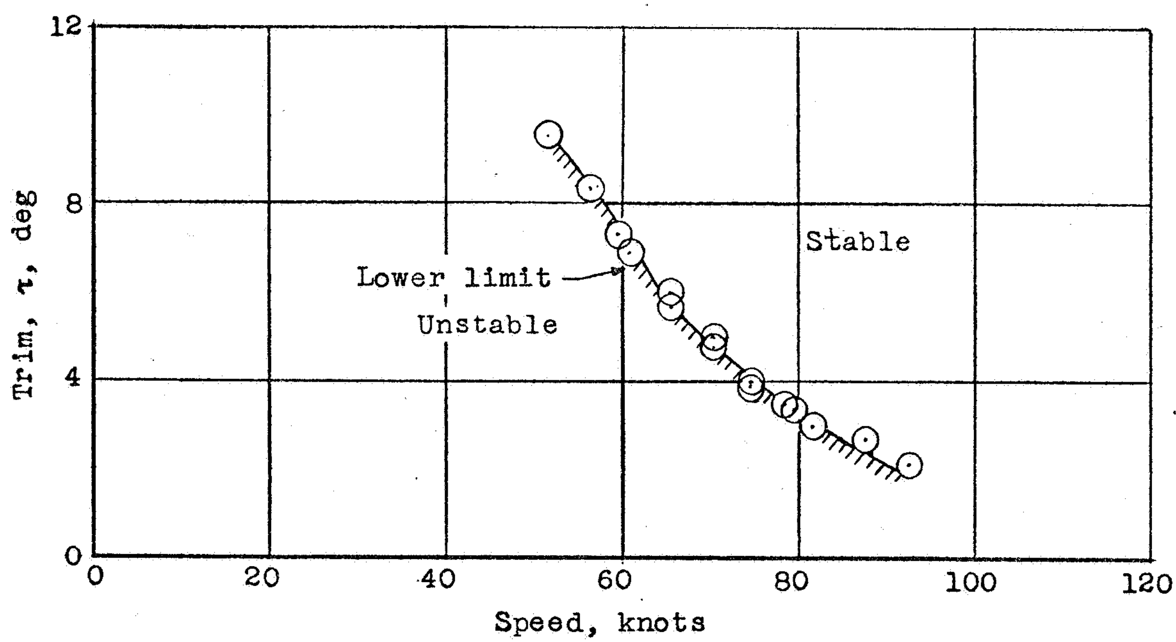


(b) Power off.

Figure 9.- Trim limits of stability. Round-keel configuration; $\delta_f = 30^{\circ}$.

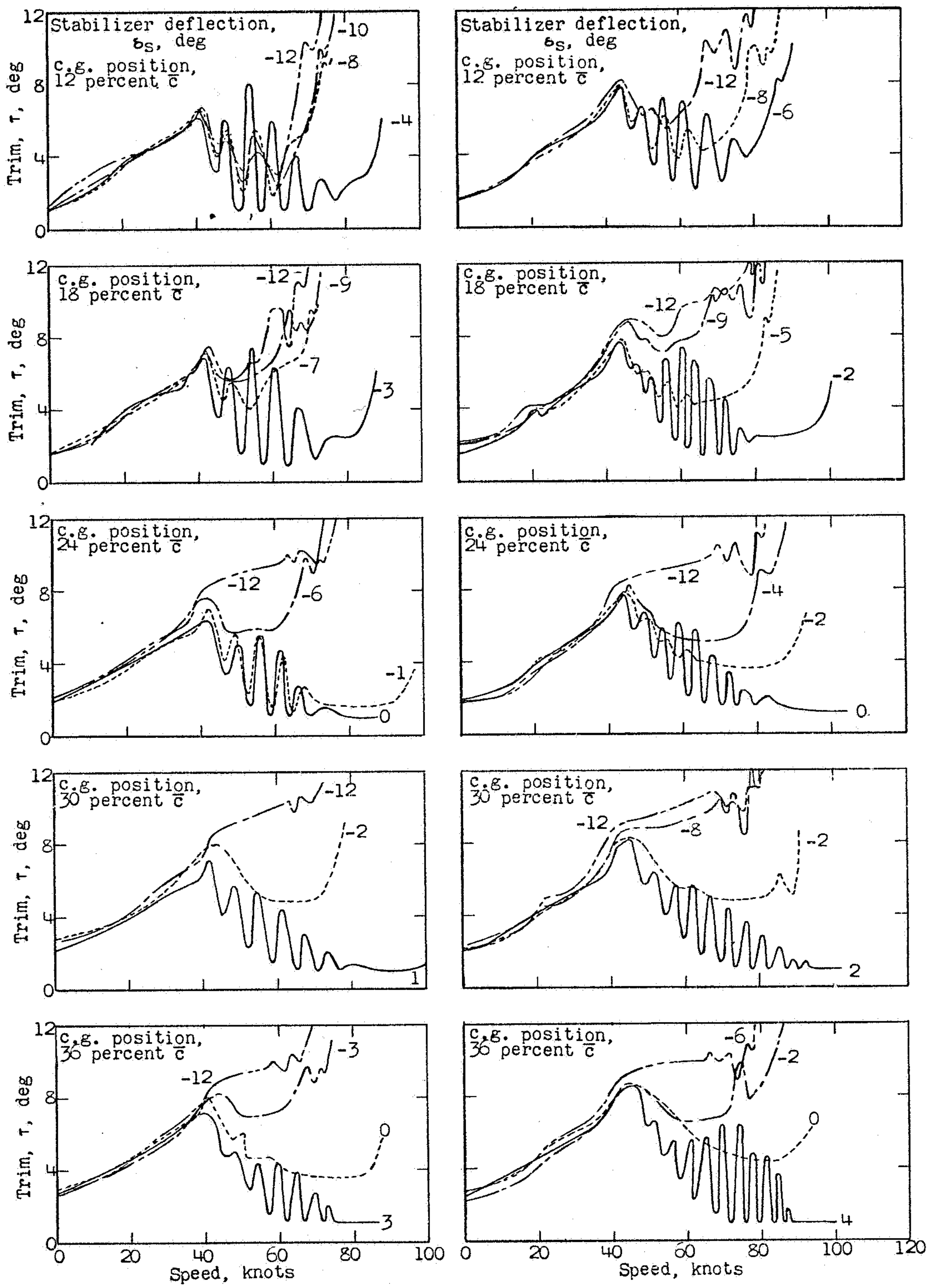


(a) Power on.



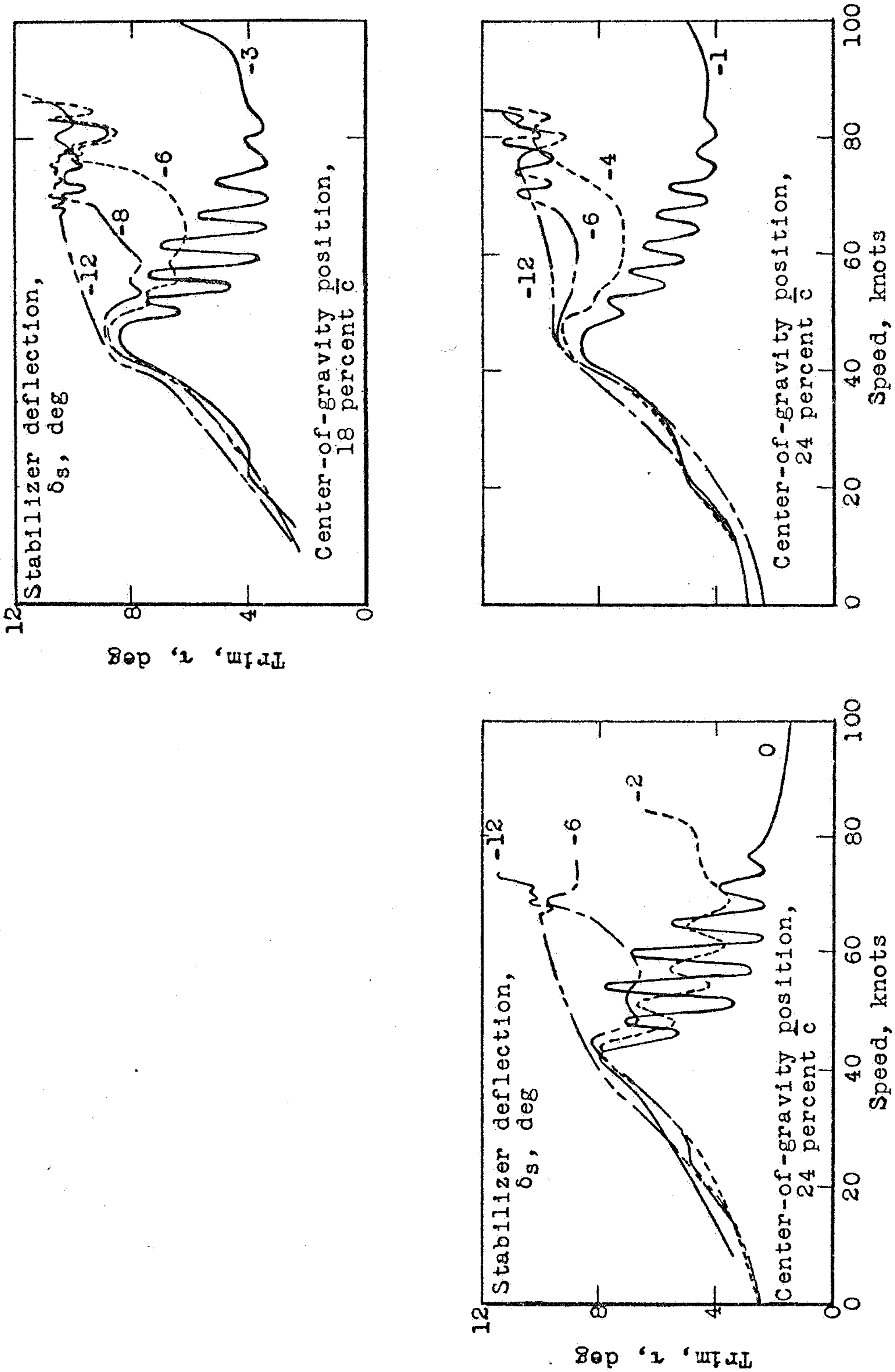
(b) Power off.

Figure 10.- Trim limits of stability. Sharp-keel configuration; $\delta_f = 30^\circ$.



(a) Gross load, 70,000 pounds. (b) Gross load, 85,000 pounds.

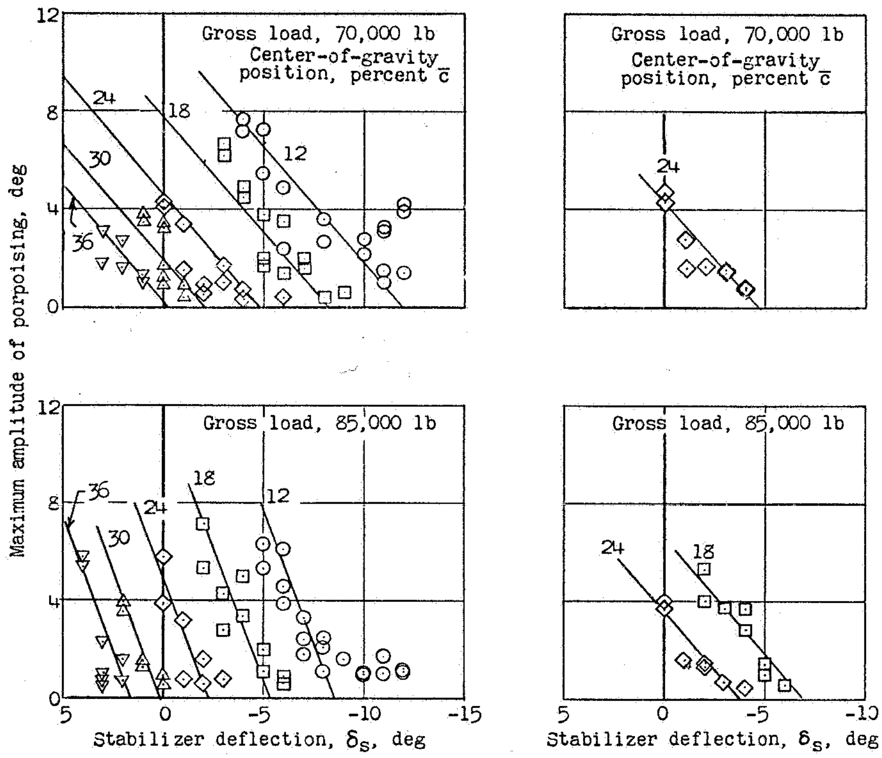
Figure 11.- Representative trim tracks during take-offs. Round-keel configuration; $\delta_f = 30^{\circ}$.



(a) Gross load, 70,000 pounds.

(b) Gross load, 85,000 pounds.

Figure 12.- Representative trim tracks during take-offs. Sharp-keel configuration; $\delta_f = 30^{\circ}$.



(a) Round-keel configuration. (b) Sharp-keel configuration.

Figure 13.- Variation of maximum amplitude of porpoising with stabilizer deflection; $\delta_f = 30^{\circ}$.

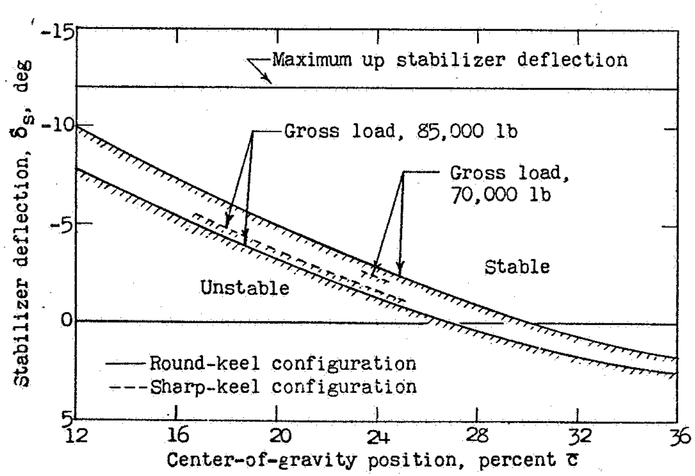
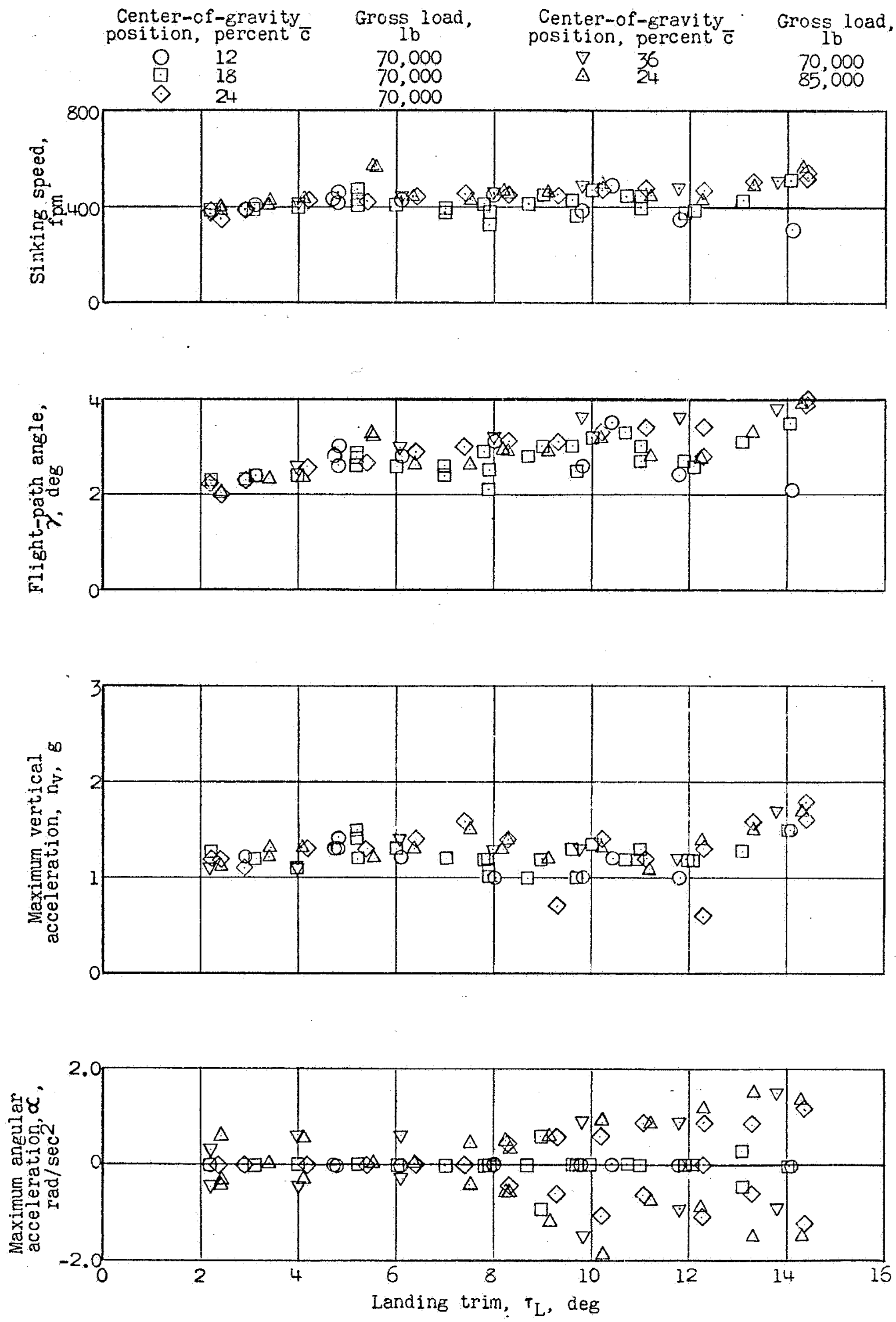
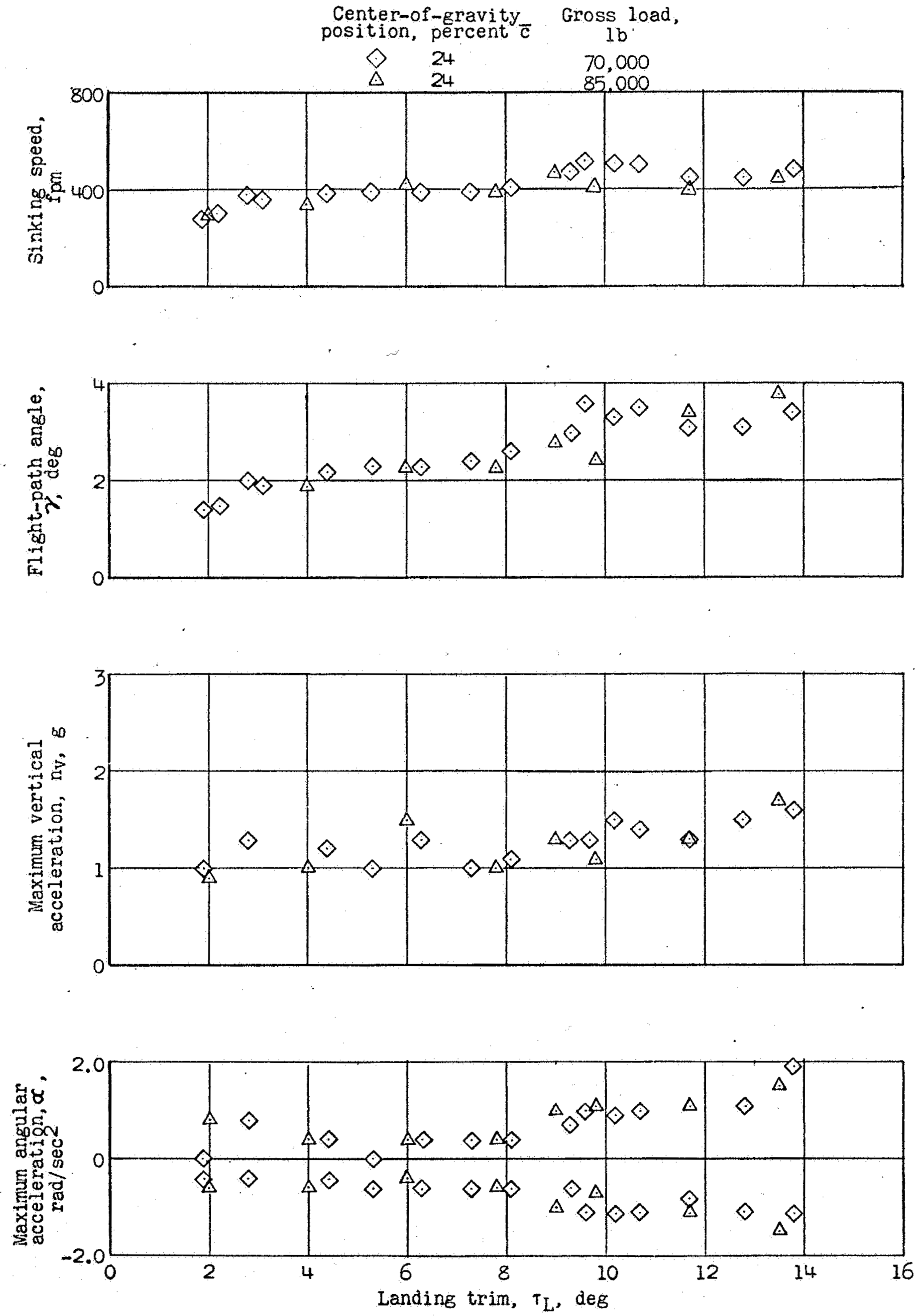


Figure 14.- Range of position of center of gravity for stable take-offs. Maximum amplitude of porpoising, 2°; $\delta_f = 30^{\circ}$.



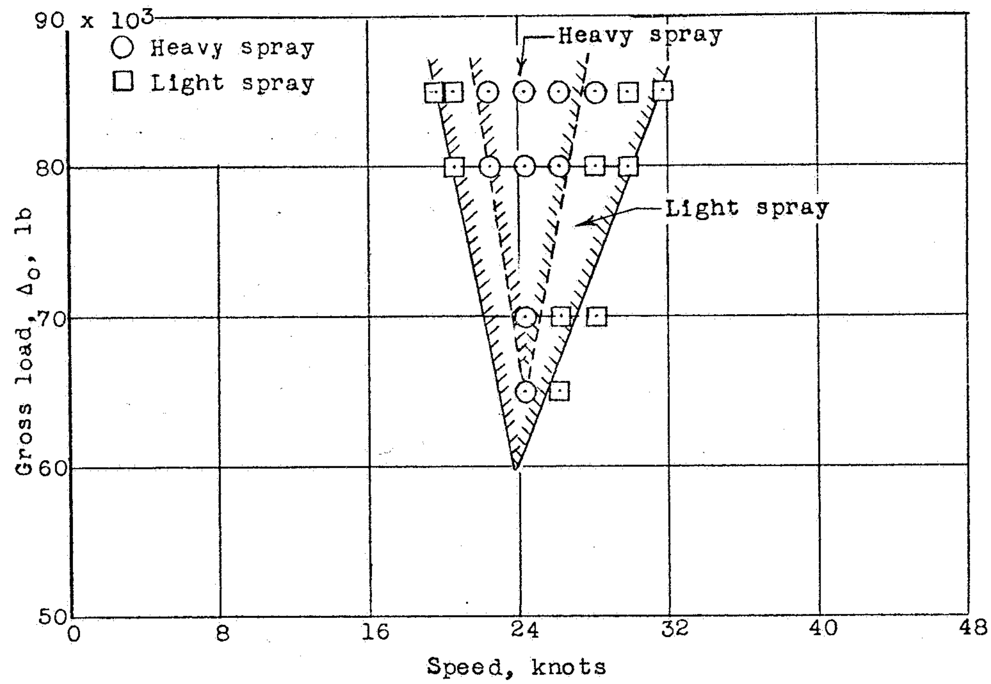
(a) Round-keel configuration.

Figure 15.- Smooth-water landing characteristics. $\delta_f = 30^\circ$; power off.

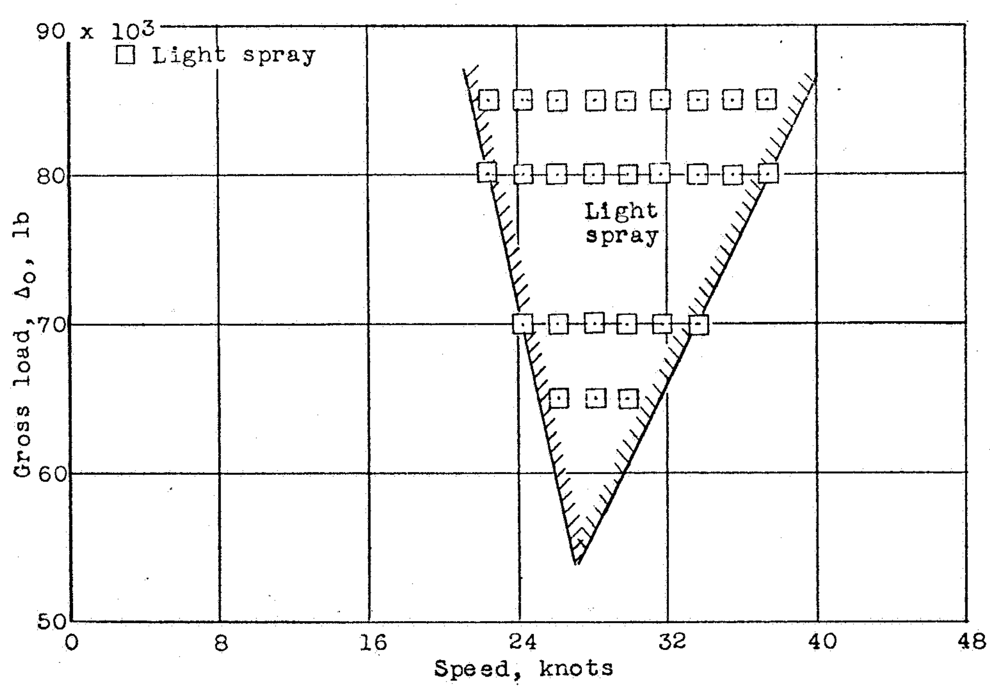


(b) Sharp-keel configuration.

Figure 15.- Concluded.

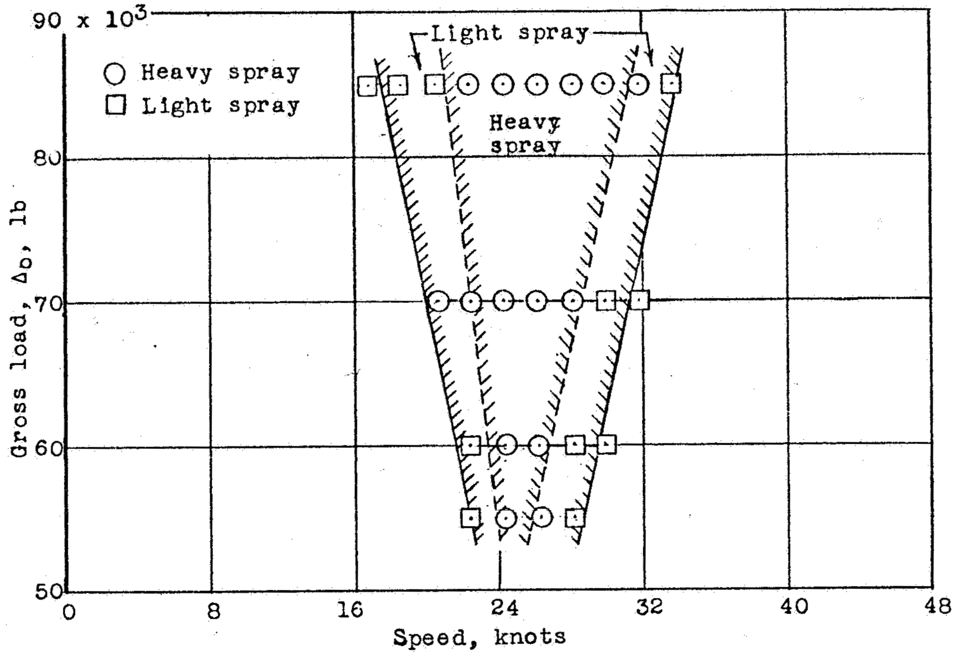


(a) Spray in propellers.

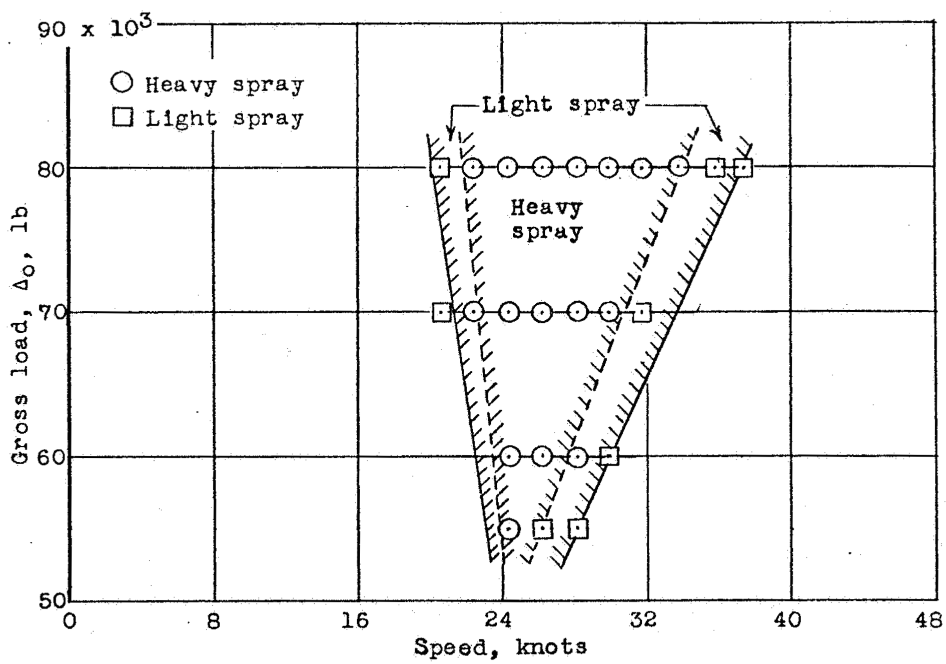


(b) Spray on flaps.

Figure 16.- Range of speeds and gross loads over which spray strikes the propellers and flaps. Round-keel configuration; $\delta_s = 0^\circ$; $\delta_f = 30^\circ$; center-of-gravity position, $0.36\bar{c}$; take-off power.

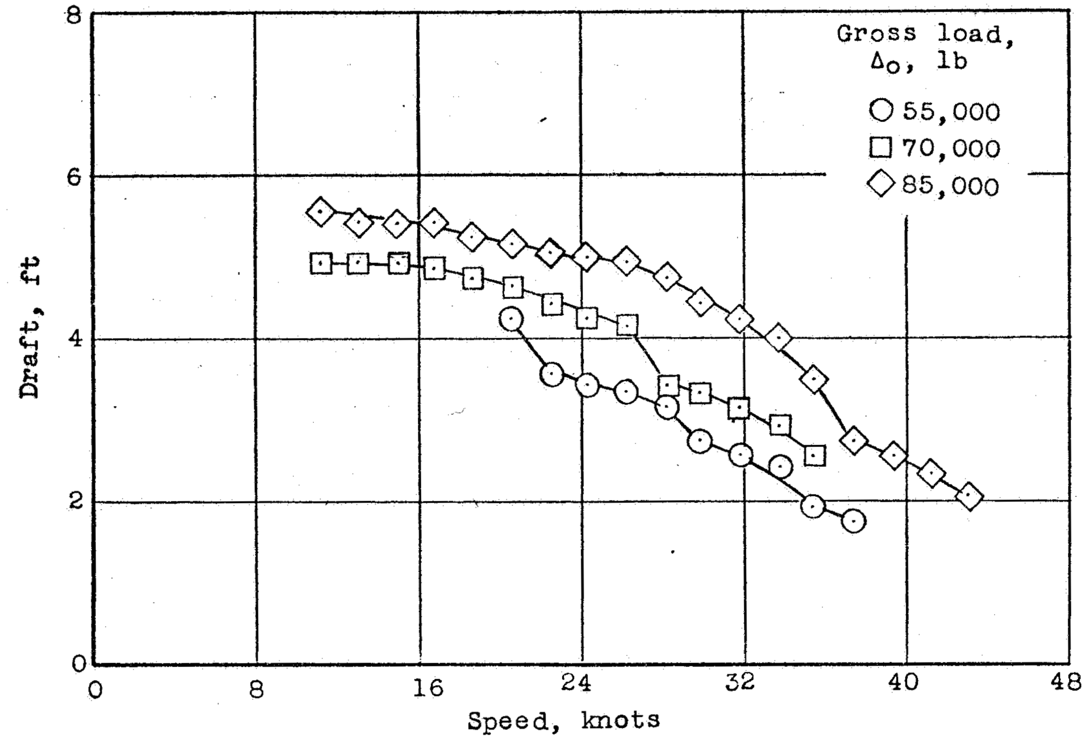


(a) Spray in propellers.

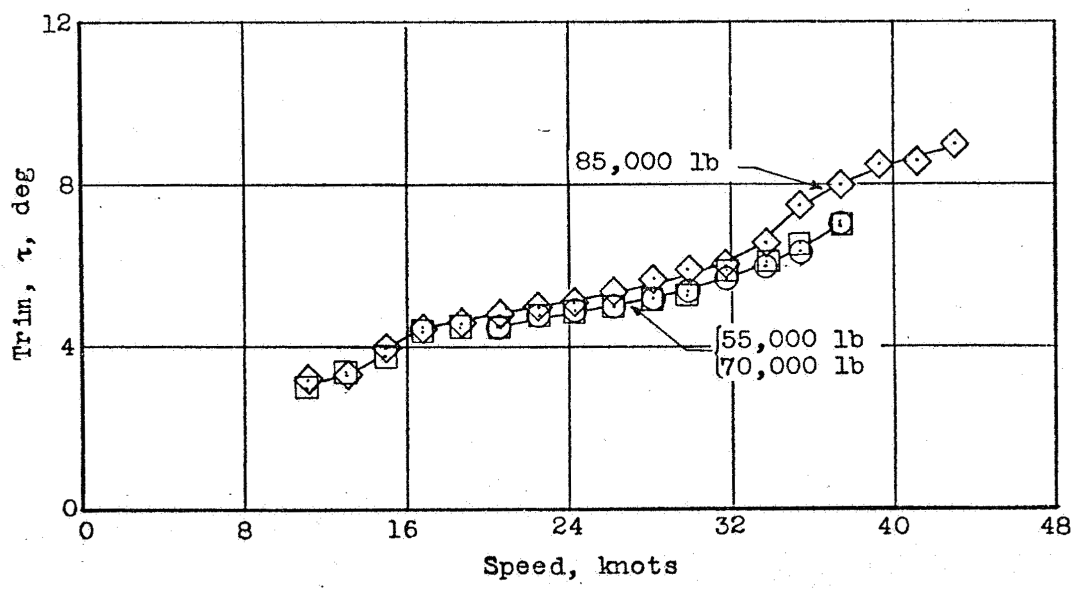


(b) Spray on flaps.

Figure 17.- Range of speeds and gross loads over which spray strikes the propellers and flaps. Sharp-keel configuration; $\delta_s = 0^\circ$; $\delta_f = 30^\circ$; center-of-gravity position, $0.36\bar{c}$; take-off power.

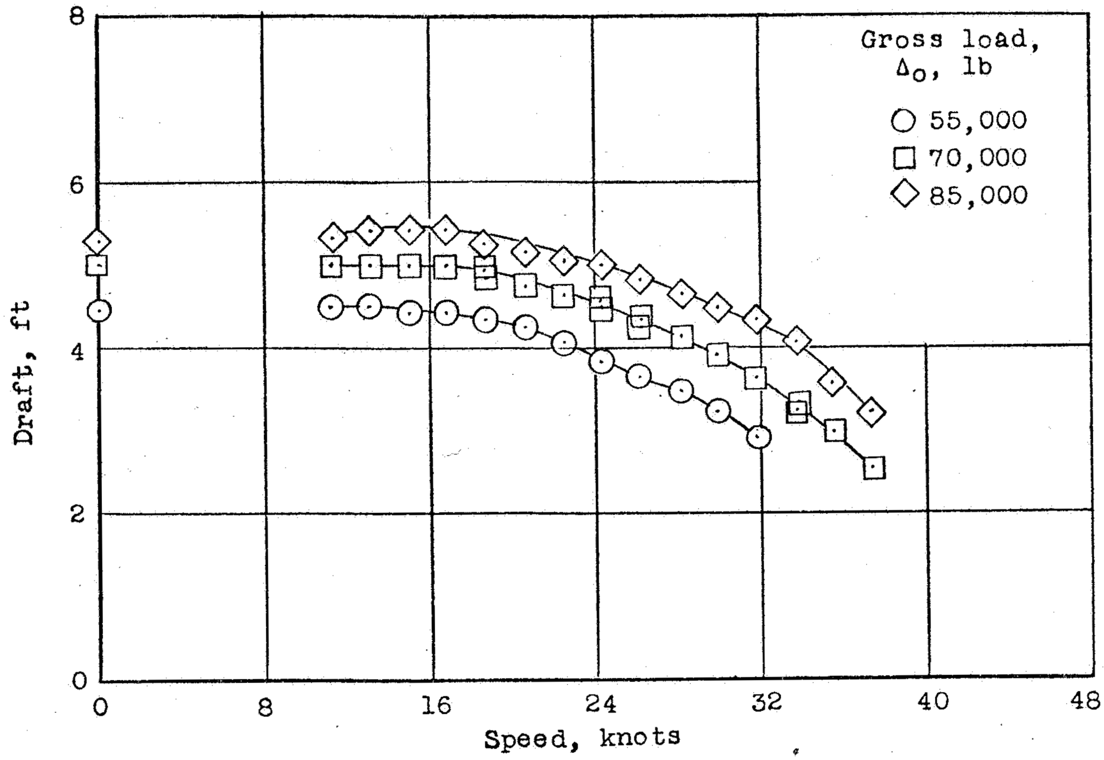


(a) Draft.

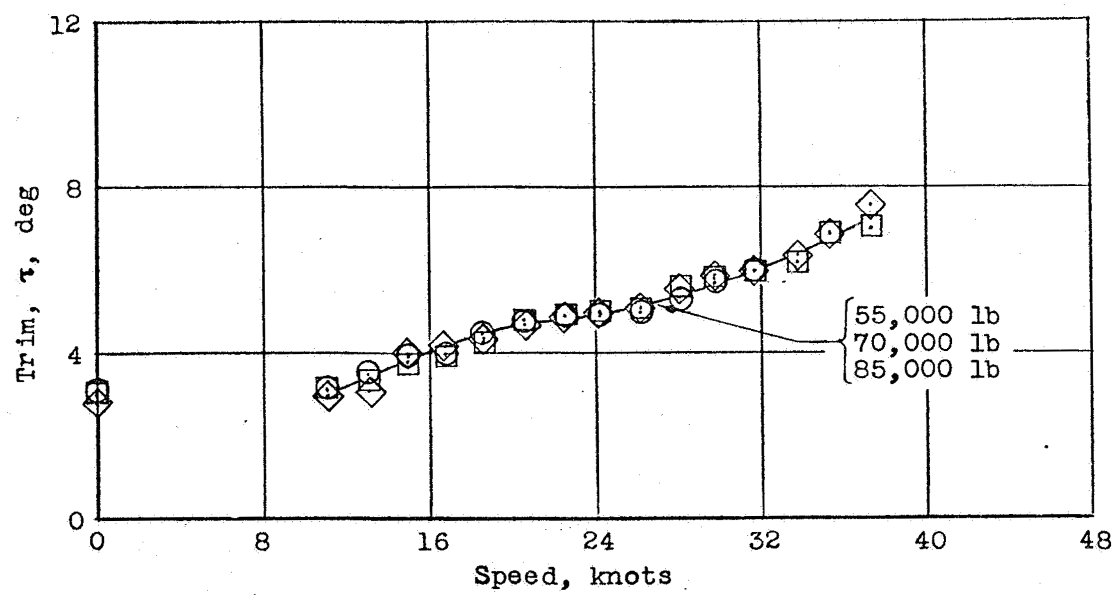


(b) Trim.

Figure 18.- Variation of draft and trim in the speed range where spray strikes the propellers and flaps. Round-keel configuration; $\delta_s = 0^o$; $\delta_f = 30^o$; center-of-gravity position, $0.36\bar{c}$; take-off power.



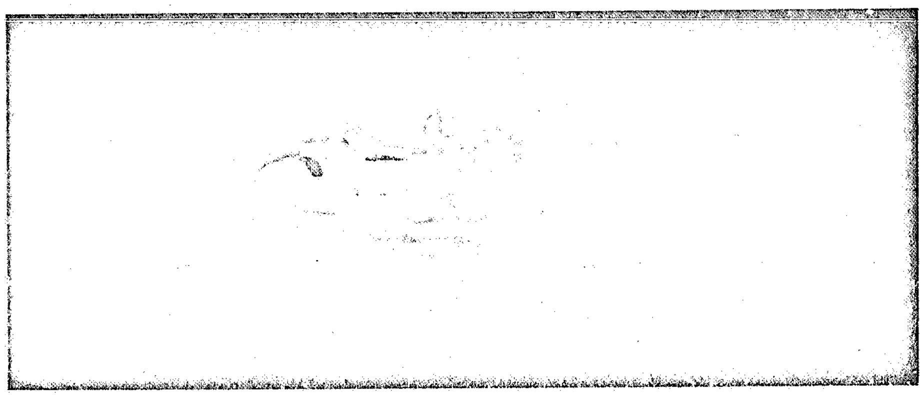
(a) Draft.



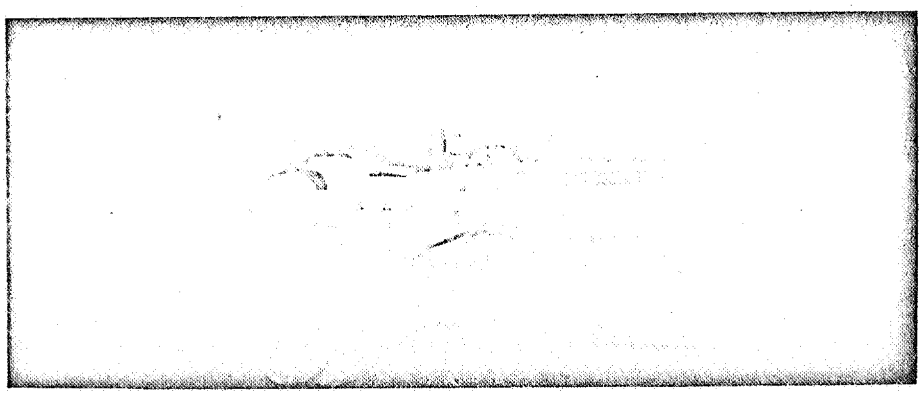
(b) Trim.

Figure 19.- Variation of draft and trim in the speed range where spray strikes the propellers and flaps. Sharp-keel configuration; $\delta_s = 0^\circ$; $\delta_f = 30^\circ$; center-of-gravity position, $0.36\bar{c}$; take-off power.

Speed, 22.5 knots; trim, 4.8°.



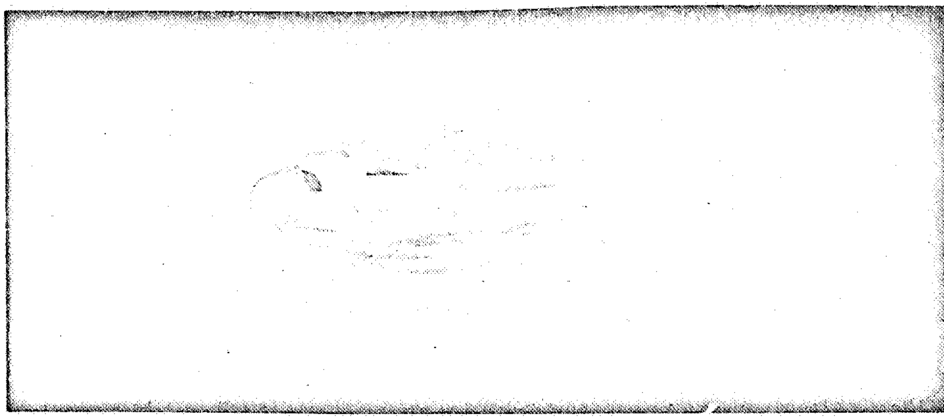
Speed, 26.2 knots; trim, 5.0°.



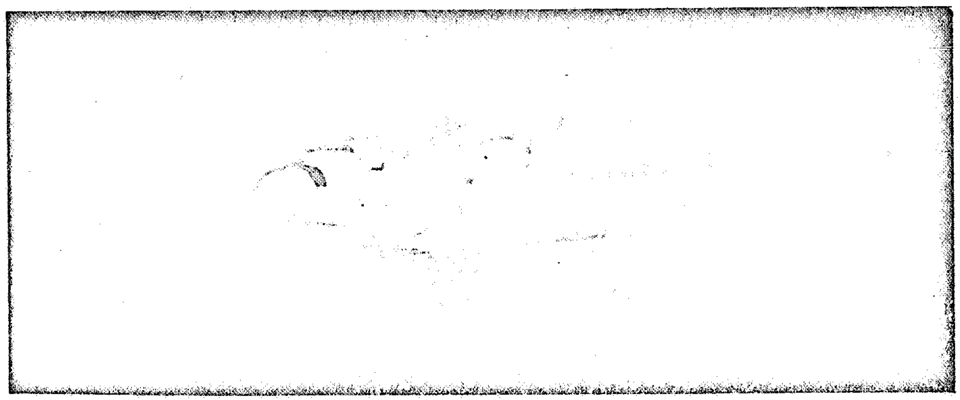
Speed, 29.9 knots; trim, 5.8°.

(a) Round-keel configuration; gross load, 70,000 pounds. L-85586

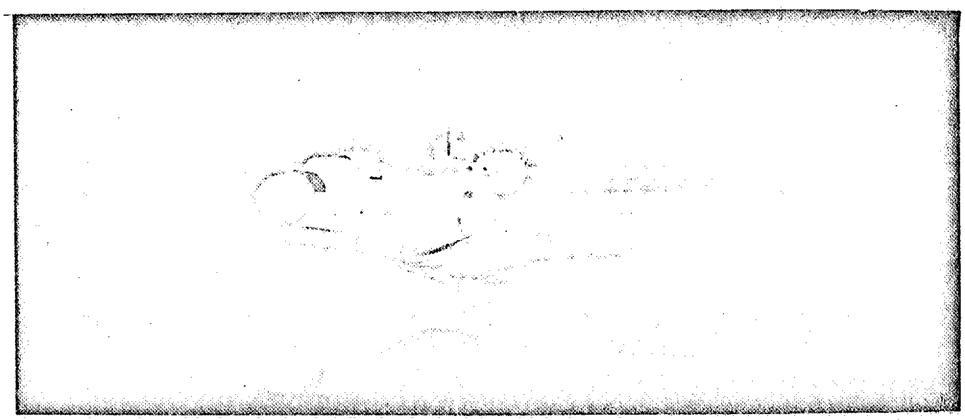
Figure 20.- Spray photographs. $\delta_s = 0^\circ$; $\delta_f = 30^\circ$; center-of-gravity position, $0.36\bar{c}$.



Speed, 22.5 knots; trim, 4.8°.



Speed, 26.2 knots; trim, 5.0°.

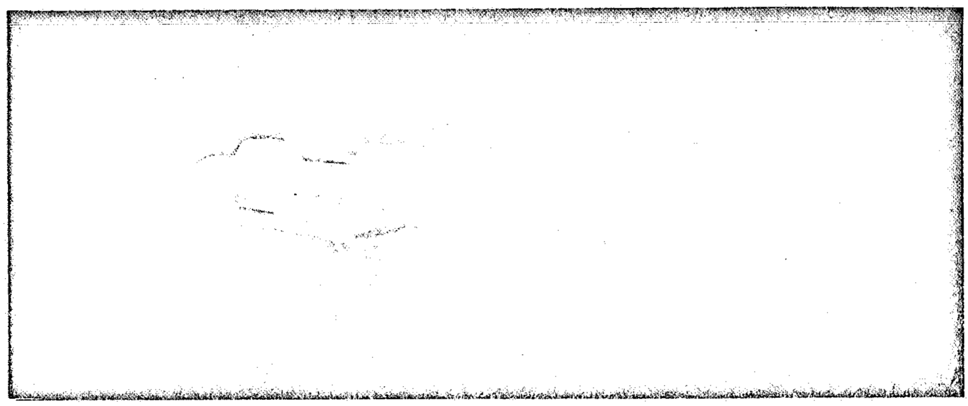


Speed, 29.9 knots; trim, 6.1°.

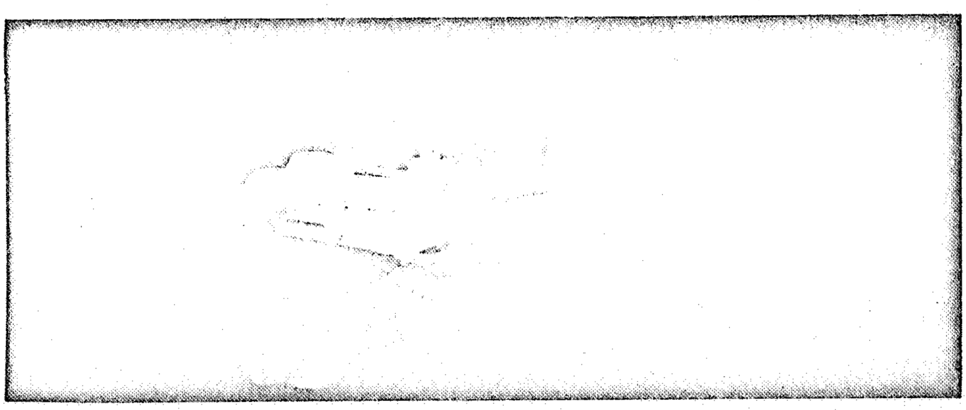
(b) Round-keel configuration; gross load, 85,000 pounds. L-85587

Figure 20.- Continued.

Speed, 22.5 knots; trim, 4.5°.



Speed, 26.2 knots; trim, 5.0°.

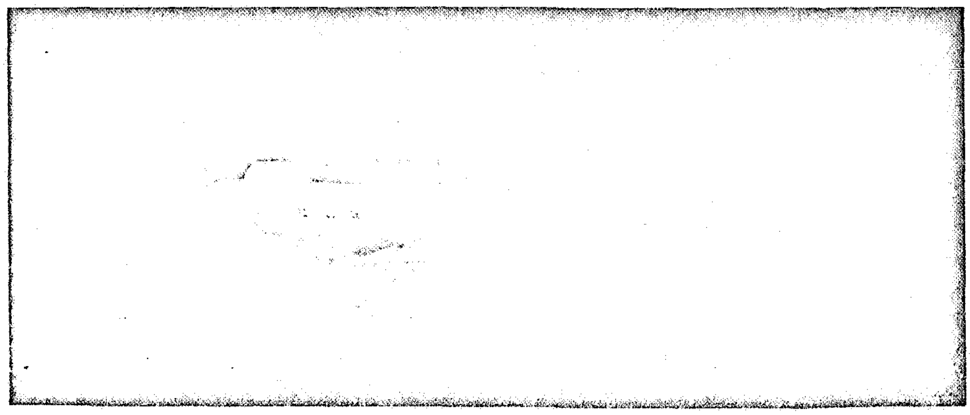


Speed, 29.9 knots; trim, 5.4°.

(c) Sharp-keel configuration; gross load, 70,000 pounds. L-85588

Figure 20.- Continued.

Speed, 22.5 knots; trim, 5.0°.

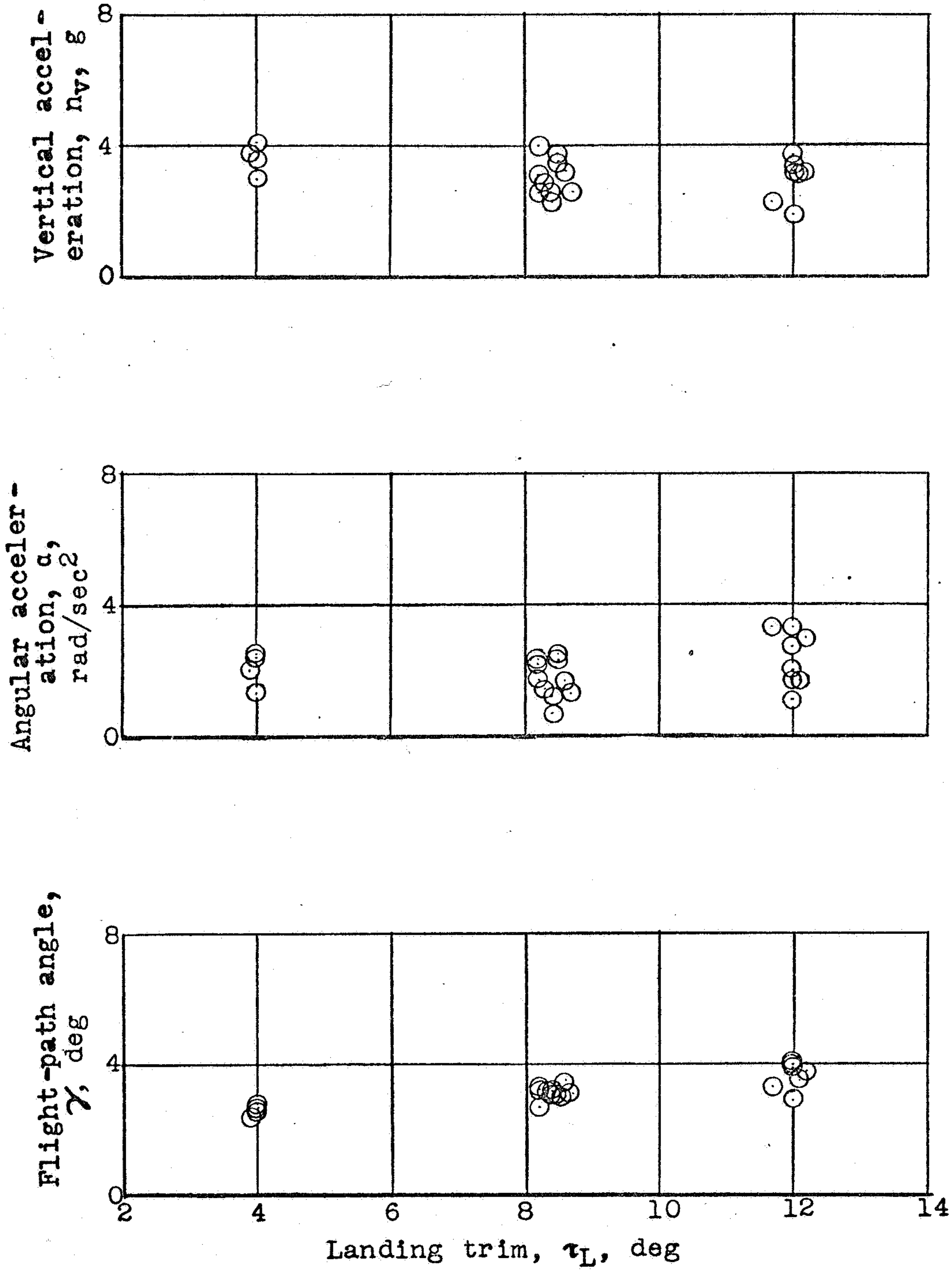


Speed, 26.2 knots; trim, 5.4°.

Speed, 29.9 knots; trim, 5.9°.

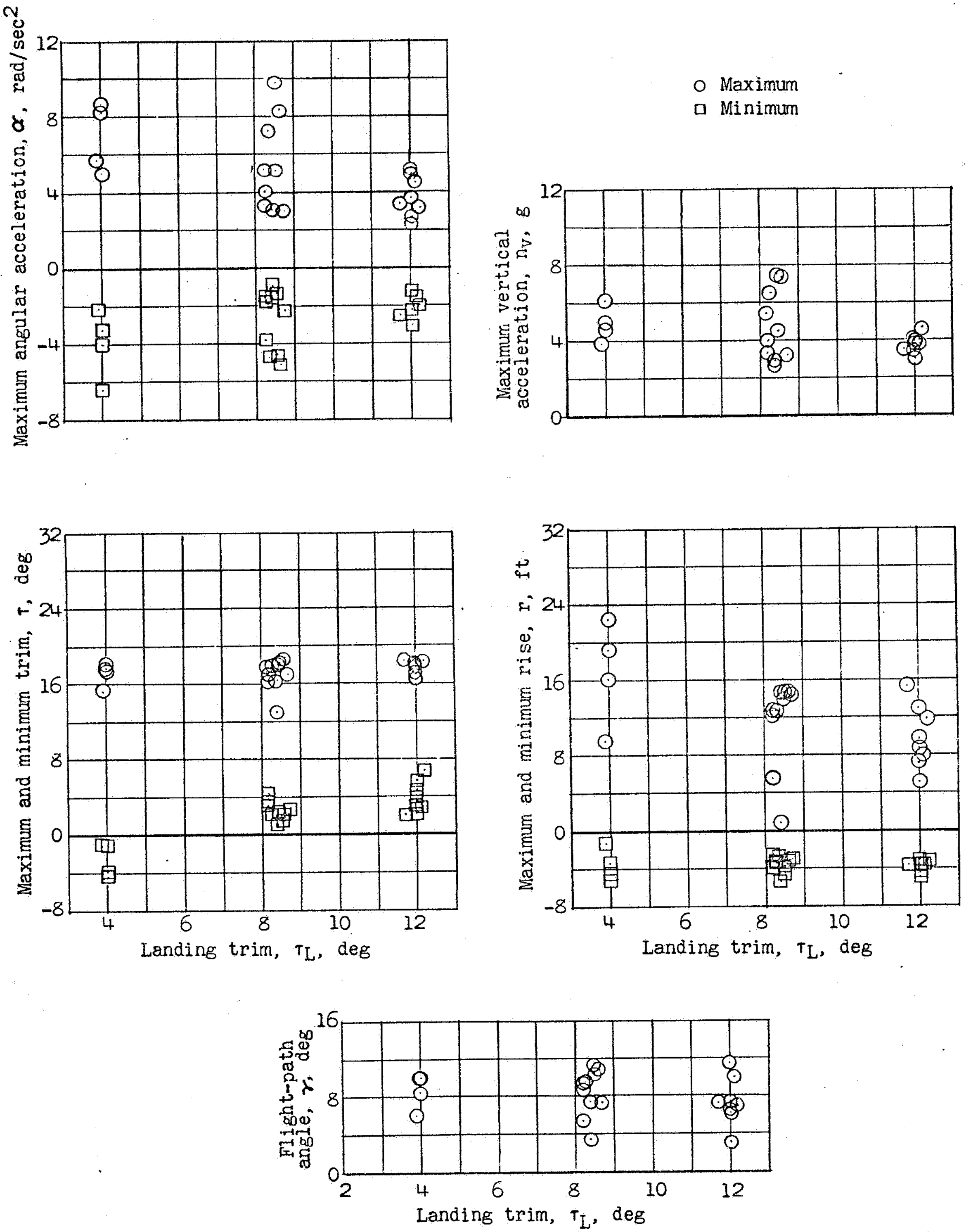
(d) Sharp-keel configuration; gross load, 85,000 pounds. L-85589

Figure 20.- Concluded.



(a) Initial impact.

Figure 21.- Effect of landing trim on rough-water behavior. Round-keel configuration; Δ_o = 70,000 pounds; $\delta_f = 30^\circ$; center-of-gravity position, $0.24\bar{c}$; wave height, 4 feet; wave length, 230 feet.



(b) At impact for maximum vertical acceleration.

Figure 21.- Concluded.

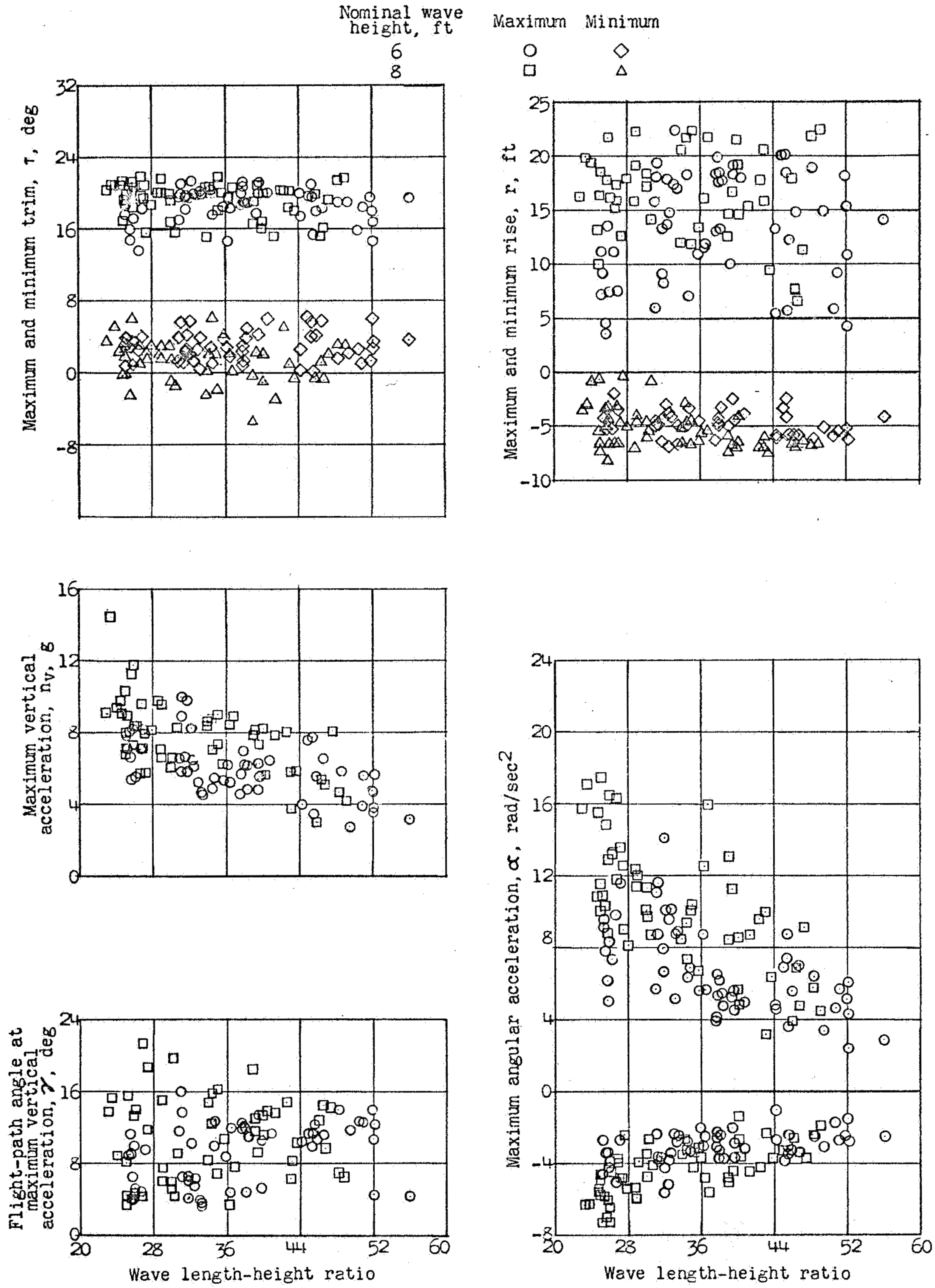


Figure 22.- Effect of wave length-height ratio on rough-water landings. Round-keel configuration; Δ_o = 70,000 pounds; center-of-gravity position, 0.24$\bar{c}$; $\delta_f = 30^o$; $\tau_L = 11^o$; power off.

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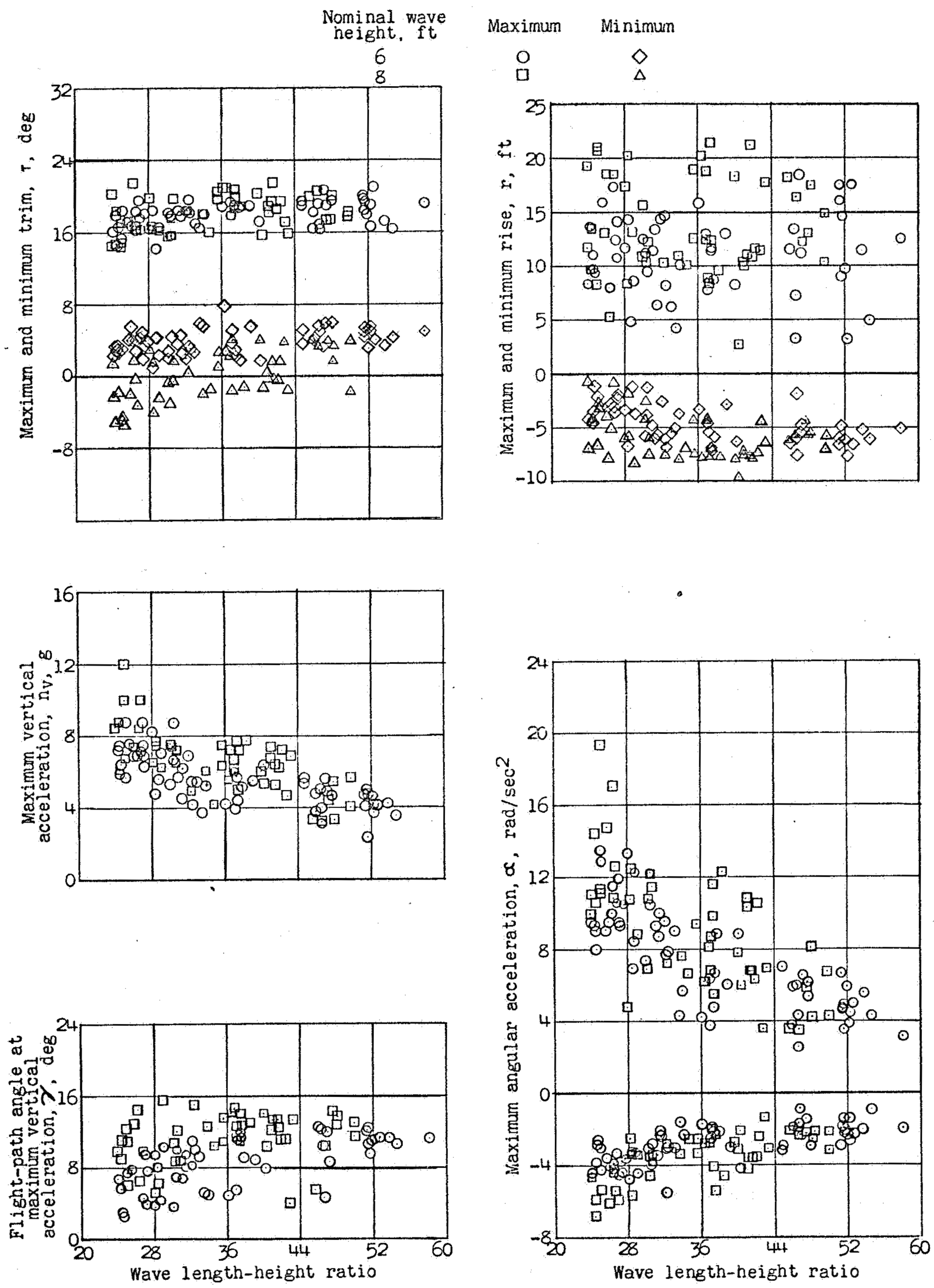

Figure 23.- Effect of wave length-height ratio on rough-water landings. Sharp-keel configuration; Δ_o = 70,000 pounds; center-of-gravity position, 0.24$\bar{c}$; δ_f = 30°; τ_L = 11°; power off.

Restriction/Classification
Cancelled